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CHANNEL CATFISH

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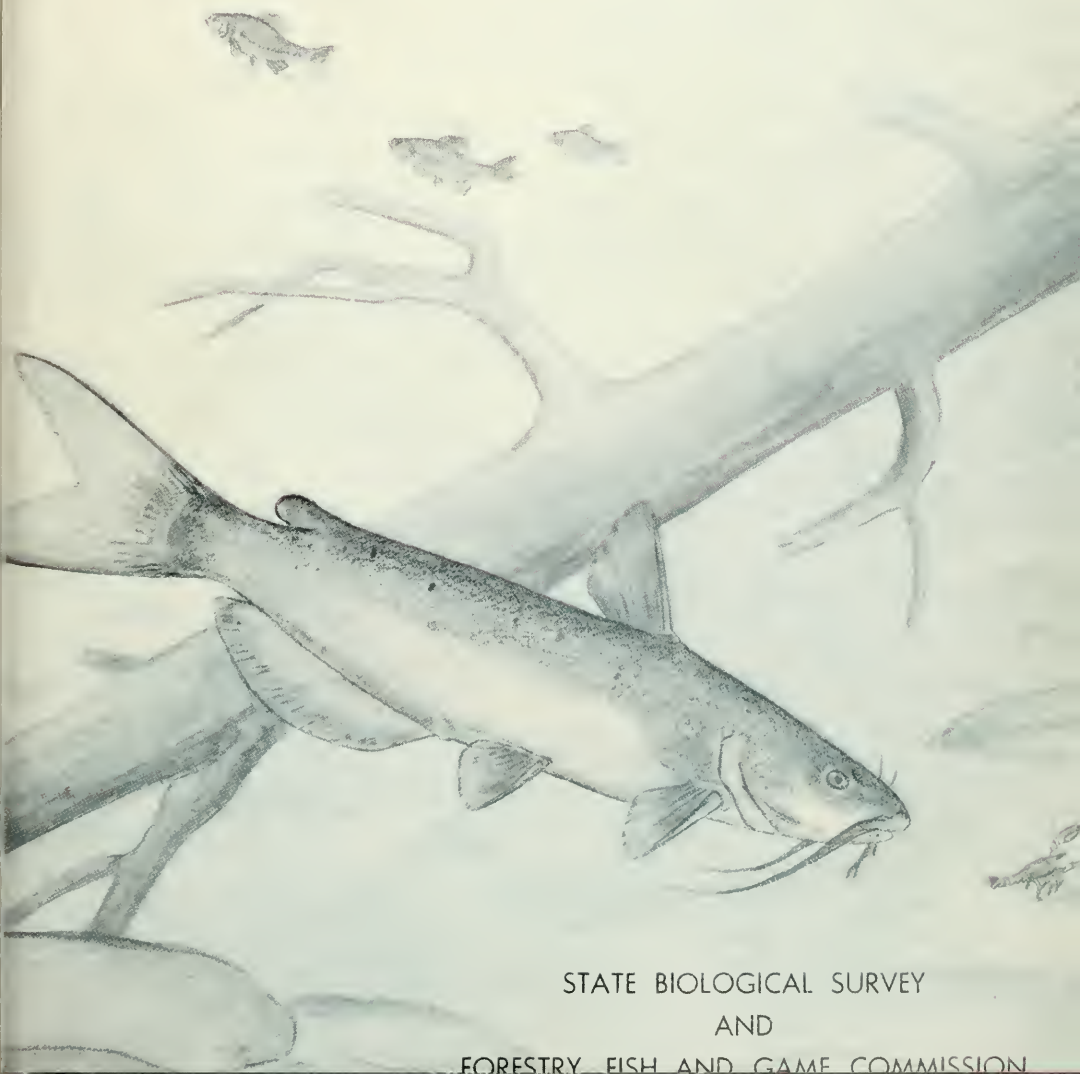

STATE BIOLOGICAL SURVEY
AND
FORESTRY, FISH AND GAME COMMISSION

Management of Channel Catfish In Kansas

BY

JACKSON DAVIS

State Biological Survey and Forestry, Fish and Game Commission of Kansas

UNIVERSITY OF KANSAS
MUSEUM OF NATURAL HISTORY

EDITOR: E. RAYMOND HALL

Miscellaneous Publication No. 21, pp. 1-56, figures 1-8
Published November 2, 1959

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1959

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CONTENTS

	PAGE
Introduction	5
Rate of Growth	11
Growth in Relation to Muddiness of Water	17
Transfer of Catfish From Kanopolis Reservoir to Other Impoundments	21
Methods	21
Distribution of Marked Fish	23
Status of Channel Catfish in Kanopolis Reservoir	25
Growth of Transferred Channel Catfish	27
Crawford County State Lake No. 2	27
Prairie Lake	28
Wabaunsee Lake	30
Wyandotte County Lake	31
Questionnaires	32
Production in Ponds	34
Marking Channel Catfish	38
Marks on Fingerlings	40
Marks on Larger Fish	43
Tags	44
Summary and Recommendations	45
Appendix	48
Acknowledgements	53
Literature Cited	54

FIGURES

PAGE

1. Genital region of male and of female channel catfish 7
2. Head of male and of female channel catfish 8
3. Length-weight relationship of channel catfish 16
4. Growth of channel catfish in relation to turbidity 19
5. Contribution of each species to the anglers' catch from Kanopolis Reservoir 24
6. Questionnaire used to compare the 1954 and 1955 fishing seasons at Prairie Lake 33
7. Measuring board used in marking channel catfish 39
8. Fins removed from channel catfish in marking experiments .. 40

TABLES

1. Average Calculated Total Length in Inches of Channel Catfish at the End of each Year of Growth 12
2. Growth of Marked Channel Catfish Stocked in 1954 at Lengths of Eight to 13 Inches Recaptured in Gill Nets in 1955 and 1956 28
3. Average Increase in Length of Channel Catfish Transferred from Kanopolis Reservoir to Prairie Lake in August, 1954 29
4. Comparison of 1955 Fishing Season (Channel Catfish only) with the 1954 Season Based on Fishermen's Answers to Questionnaires 34
5. Growth of Channel Catfish Stocked as Fingerlings in Three Ponds 35
6. Growth of Stunted Channel Catfish in Ponds 37
7. Growth of Channel Catfish in Pond 1 38
8. Regeneration of Fins by Channel Catfish Marked when Fingerlings 41
9. Regeneration of Fins by Channel Catfish Eight to 13 Inches Long when Marked 42

INTRODUCTION

The channel catfish has provided Kansans with food and sport since the state was first settled, and is today sought by sport fishermen in all of our waters. The State Fish Hatchery at Pratt pioneered in propagating the channel catfish and has continued to work with it. In 1954, the Forestry, Fish and Game Commission and the State Biological Survey of Kansas began studies to obtain a better knowledge of the channel catfish in the impounded waters of the state and to develop techniques useful in managing that species so as to improve the sport fishery. Field work was done in 1954, 1955, and 1956.

The channel catfish is native to the Great Plains region of Canada, the Hudson Bay drainage, the St. Lawrence River, the Great Lakes, the Mississippi Valley, and streams tributary to the Gulf of Mexico. It has been widely introduced since the 1880's and now occurs in most rivers in the United States (Moore, 1957:141).

In Kansas the channel catfish is native to all of the major river systems, but Doze (1925:169) stated that it had become more numerous in the southwestern part of the state by 1925 than it had been in the 1880's.

The scientific name of the channel catfish is *Ictalurus punctatus.* Speirs (1952) and Legendre (1953:249-267) discussed the nomenclature and showed that the name *lacustris* should no longer be applied to the channel catfish. Taylor (1954:43) recommended the use of Ictaluridae rather than Ameiuridae for the family name.

The channel catfish can be distinguished from all other catfish in Kansas except the blue catfish *(Ictalurus furcatus)* by its forked caudal (tail) fin, the caudal fin of all others being square or rounded. The blue catfish has a straight-margined anal fin with 30 to 36 supporting rays, whereas the anal fin of the channel catfish is rounded and has only 24 to 29 rays. The channel catfish is more slender than the blue catfish. The two species also differ in color. Blue catfish lack spots and are usually pale, the coloration giving rise to the colloquial names "white cat" and "white fulton." Channel catfish are dark steely-blue to olivaceous on the back, with this color grading into the cream-colored or white belly. Black spots of one-eighth inch diameter, or smaller, dot the sides; however, large fish (four pounds or more) usually lose the spots. It is the unspotted channel catfish that fishermen frequently call "blue cats,"

"chuckleheads" or "blue channel cats." In Kansas the blue catfish is known to occur only in the northeast, having been caught in the Missouri River, the Kansas River, and the Marais des Cygnes River.

Channel catfish weighing up to five pounds are common. The largest one known weighed 55 pounds (Hutt, 1956:503), but those in excess of 20 pounds are rare. Of the other species of catfish in Kansas, only two grow larger than the channel catfish. Blue catfish and flathead catfish *(Pylodictis olivaris)* attain weights in excess of 100 pounds. Bullheads sometimes weigh two pounds or more, but stone catfish and madtoms weigh less than four ounces.

The channel catfish tolerates widely varying environmental conditions. It feeds either in clear or muddy water at night and by day. The eyes are proportionally larger than those of most other kinds of catfish. The barbels are covered with taste buds and in addition are tactile. The body surface also is sensitive to substances dissolved in the water.

In clear, rocky, well-oxygenated streams the channel catfish associates with smallmouth bass *(Micropterus dolomieui)* and other clear-water species. Slow-moving, silty streams also support large populations of channel catfish. In streams young channel catfish inhabit shallow riffles and turbulent areas near sand bars. Adults spend the day under big rocks, in deep pools, or under log jams, and enter shallow water at night to feed. The habitat of young channel catfish in lakes is poorly known. In a clear lake where young were known to occur, I was unable to catch any by seining in shallow areas. In another clear lake, Dr. Frank B. Cross (personal communication) caught channel catfish less than three inches long in gill nets set in deep water near the dam, which was riprapped. In shallow, muddy ponds that I studied, young channel catfish seemed randomly distributed.

Channel catfish are omnivorous, eating whatever animal and plant material is readily available, including dead fish and other animals. Staple foods are insects (both immature and adult stages), crustaceans, fish, and frogs. Some fish fill themselves with filamentous algae or with aquatic plants such as pondweed *(Potamogeton)* and naiad *(Najas)*. The occurrence of grasshoppers and other terrestrial insects in the stomachs of channel catfish indicates that they take some food from the surface of the water, although they usually feed near the bottom. They will eat refuse discarded by people and sometimes congregate near places where garbage is dumped

into streams and lakes. My examination of stomachs has revealed parts of a dressed rabbit, a chicken neck, a piece of liver wrapped in paper, fragments of beef bones, pieces of shrimp, and kernels of canned corn.

Bailey and Harrison (1948:125-130) found that young channel catfish (less than four inches long) in the Des Moines River, Iowa, fed almost exclusively on aquatic insect larvae—chiefly midges, black flies, mayflies and caddis flies. Fish four to 12 inches long continued to eat principally insects, but as the fish grew larger, insects of larger size (mayflies and caddis flies) were eaten more often. Small fish and seeds became significant items in catfish four

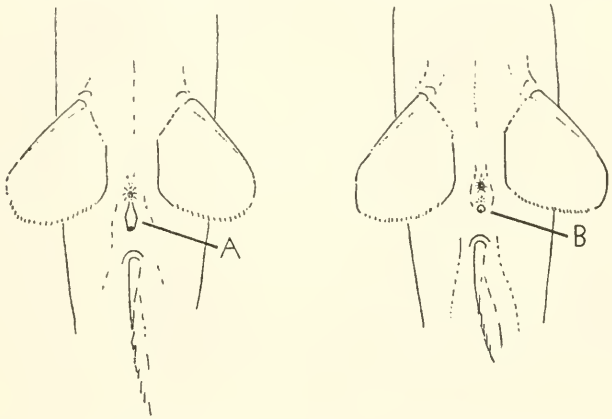

FIG. 1. Genital region of male (A) and of female (B) channel catfish, × ¼.

to 12 inches long. In catfish more than 12 inches long, fish and large insects were of major importance, but many seeds and other items were eaten. Although larger fish ate fewer insects, those taken were more diversified and included a higher percentage of terrestrial kinds. The frequency of food-items in stomachs reflected the abundance of these items in the environment.

Channel catfish feed most actively, according to Bailey and Harrison (1948:135-136), from sundown to midnight. These authors concluded that adults did not feed during the breeding season.

Most anglers know that channel catfish feed voraciously when a heavy rain washes material into the water. Gill nets in Crawford County State Lake No. 2 on the night of May 1, 1954, when rain raised the waterlevel eight inches, caught many channel catfish that were gorged with sow bugs and terrestrial insects, such as

grasshoppers, beetles, caterpillars, crickets, mole crickets, and wasps.

The most reliable method of discerning the sex of channel catfish, on the basis of external characteristics, is by examination of the genital pore, which is situated immediately in front of the anal fin. In the male a genital papilla extends posteriorly. Milt is extruded through an opening, the genital pore, at the end of the papilla. In the female the genital opening scarcely protrudes from the belly (see Figure 1). The sexes differ in other details also. The head of a mature male is wider than the body, and the region above and behind the eyes is swollen at spawning time. The head of a female is narrower than that of a male, and never becomes

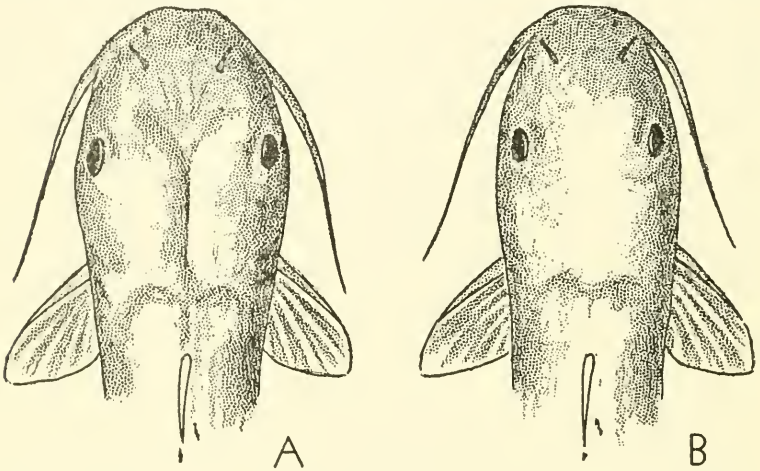

FIG. 2. Dorsal view of head of male (A) and of female (B) channel catfish, × ¾.

swollen (Figure 2). As spawning time approaches, the abdomen of the female becomes increasingly distended with eggs. The belly of the male retains its usual contour.

Males are usually somewhat darker than females from the same body of water. Some females become yellowish on the undersides. Comparison of the color of fish from different bodies of water is not reliable because color varies with the clarity of the water and kind of environment. For example, a female from clear water is usually darker than a male from muddy water.

Although some channel catfish become sexually mature in their second year, most spawn for the first time when they are three years old (Doze, 1925:177; Brown, 1942:311). If growth is slow,

four or five years are required to attain sexual maturity. Channel catfish usually are between 11 and 16 inches long when they spawn for the first time. Males become sexually mature at a slightly smaller size than females (Harlan and Speaker, 1956:107).

Because channel catfish are secretive in their spawning, observation of breeding in natural surroundings is difficult, and most of the information about spawning comes from observations made at hatcheries. There is no indication that spawning activities of wild fish differ from those of hatchery brood-stock. Channel catfish spawn in dark places that are protected from intrusion on one or more sides. In streams and lakes suitable sites are crevices in log-drifts, cavities beneath roots of trees undercut by the current, crevices under rocks, and cavities or burrows in banks. In hatcheries, nail kegs, earthenware crocks, or milk cans are provided for the fish to spawn in.

Prior to spawning the male selects a nest-site, cleans it by vigorous fanning with his fins and body, and waits for a female that is ready to deposit eggs. Pairing may occur before the female is actually ripe, and she may stay nearby while the male cleans the nest. The female usually takes no part in preparation of the nest or in the defense of it and the young.

The spawning act as it occurred in an aquarium has been described by Clemens and Sneed (1957:5-6). Other workers (Brown, 1942:312; Lenz, 1947:231-232) have observed spawning in ponds. Behavior of the fish before and after the actual spawning embrace has been recorded by Brown (1942:311-312), Lenz (1947:231-232), Toole (1951:4-6), and Clemens and Sneed (1957:2-8).

Females seem to spawn but once a year and with only one male. In some hatcheries where the eggs are removed from the nest, one male has been observed to serve as many as three females. Whether wild males normally spawn more than once is unknown (Brown, 1942:312; Clemens and Sneed, 1957:9).

In the latitude of Kansas spawning occurs from late May through July and perhaps later, with the peak in June and July (Doze, 1925:173; Brown, 1942:312; Marzolf, 1957:25). Spawning usually starts when the temperature of the water is 70°F. (Doze, 1925:173). The optimum temperature is approximately 80°F. (Clemens and Sneed, 1957:6).

According to Brown (1942:312), a female produces from ⅓ pound to 6½ pounds of eggs per spawn (approximately 8,000 eggs comprise one pound). Clemens and Sneed (1957:6) reported that females

weighing one to four pounds produced about 4,000 eggs per pound of body weight and that larger fish usually spawned about 3,000 eggs per pound of body weight. The eggs are golden in color when first deposited but become pink as the embryo develops. Eggs have a tough coating and adhere to one another forming an oval mass.

The time required for eggs to hatch is regulated by temperature. Development does not occur at temperatures cooler than 60°F., and molds usually infect eggs at temperatures in excess of 90°F. Between the extremes of 60° and 90° hatching time varies between five and ten days (Brown, 1942:313; Canfield, 1947:29; Lenz, 1947:232; Toole, 1951:7). Clemens and Sneed (1957:7) tabulate periods of incubation at various temperatures. According to Canfield (1947:29), fluctuating temperatures and temperatures much below 75° are unfavorable.

At the time of hatching, the fry are golden in color and almost transparent, but they become grayish-blue within two weeks. The yolk sac lasts from three to six days (Doze, 1925:173; Brown, 1942:313; Lenz, 1947:232).

The U. S. Bureau of Fisheries raised young channel catfish (spotted catfish) at the Fish Ponds, Washington, D. C., in 1892 and 1893 but could make no observations concerning the spawning of the fish (Rathbun, 1894:XXXIX; Worth, 1895:96). Other attempts to raise channel catfish usually resulted in failure until workers at the Fairport, Iowa, station of the U. S. Bureau of Fisheries discovered in 1916 that the species could be raised in ponds by providing proper nesting conditions (Smith, 1917:84-85). The Kansas fish hatchery started raising channel catfish about 1925 and other midwestern states followed.

Two methods of raising channel catfish have proved satisfactory. In the pen method (Toole, 1951:3-6) a pair of fish is placed in an enclosure containing a nail-keg or other nest-structure. After spawning is completed, the female is removed so that she cannot eat the eggs, and the male is left to care for the eggs until they hatch. The young are then placed in troughs for the first stage of rearing.

In the pond method of rearing (Doze, 1925:170-172; Brown, 1942: 311-312) brood fish are allowed to pair of their own accord in a pond that is supplied with nest-structures. Eggs are removed from the nests as soon as possible after they are deposited and are

hatched in jars or in wire baskets, through which water flows continuously.

Hatcherymen disagree about the necessity for holding brood fish in running water to bring them into spawning condition. Canfield (1947:28), Lenz (1947:231), and Toole (1951:3) reported that exercising brood fish by holding them in raceways is essential to insure spawning. Brown (1942:311) reported that channel catfish that were moved from streams to ponds usually did not spawn in the first year after transfer but did spawn the second year. According to Marzolf (1957:24-25), channel catfish require a period of acclimatization before they will spawn, if they are moved from one body of water to another. Clemens and Sneed (1957:1) induced channel catfish to spawn by injecting females with pituitary material from fish.

RATE OF GROWTH

One objective of my study was to ascertain the rate of growth of channel catfish throughout Kansas and to compute an average rate. The data obtained could serve as standards of comparison useful in the management of this fish. Since my project was begun, Schoonover and Thompson (1954:177-178) have ascertained ages of channel catfish from Fall River Reservoir, and Tiemeier and Elder (1957:389-391) have reported the growth of channel catfish in ponds in the Flint Hills. The Fisheries Research Laboratory, Norman, Oklahoma, has issued a comprehensive report on the growth of channel catfish in Oklahoma (Finnell and Jenkins, 1954).

By counting rings that are deposited annually in the bony finspines (Sneed, 1951:176-177), I ascertained the ages of 1,567 channel catfish from 28 impoundments larger than ten acres and from six streams. Fish were obtained by netting, seining, draining, and chemical treatment by personnel of the State Biological Survey and the Forestry, Fish and Game Commission.

The spine was removed from a pectoral fin of each fish and placed in an envelope upon which pertinent data were recorded. A thin cross-section of the spine was cut by means of a small electric saw similar to the one described by Leonard and Sneed (1951). The cross-section was put under water and examined under low magnification, usually 13 ×, with reflected light.

A check on the accuracy of the technique used to ascertain age was provided by a sample of fish taken by Schoonover and Burner from Woodson County State Lake in June, 1954. Fish of only

TABLE 1. AVERAGE CALCULATED TOTAL LENGTH IN INCHES OF CHANNEL CATFISH AT THE END OF EACH YEAR OF GROWTH.

	No. of Fish	Age in Years													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
STATE LAKES															
Clark†‡	65	.....	10.1	12.7	14.4	14.1	15.1	14.7	15.4	.....	.....	.....	.....	.....	.....
Crawford No. 2†‡	132	.....	9.1	11.3	14.9	12.4	14.2	15.0	15.8	16.9	.....	.....	.....	.....	.....
Decatur No. 2*	42	3.4	.....	9.6	11.6	13.3	14.9	18.0	17.1	.....	.....	.....	22.4	.....	.....
Kingman†	8	3.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Leavenworth†‡	133	.....	8.6	11.5	13.1	15.5	15.0	17.4	18.5	.....	30.7	.....	.....	.....	.....
Lyon‡	18	.....	7.6	9.7	14.2	13.2	16.0	15.5	17.8	.....	.....	.....	.....	.....	.....
Meade‡	6	.....	8.7	.....	15.5	15.8	.....	.....	.....	.....	.....	.....	.....	.....	.....
Nemaha†‡?	42	.....	7.0	8.3	11.3	11.2	14.8	15.1	16.1	.....	.....	.....	.....	.....	.....
Neosho†	13	.....	8.2	10.6	13.0	13.1	11.3	17.3	.....	.....	.....	.....	.....	.....	.....
Ottawa†	46	1.6	6.0	8.7	10.5	13.7	13.4	.....	12.9	21.9	.....	.....	.....	.....	.....
Pottawatomie†	2	.....	.....	.....	.....	.....	.....	21.2	23.2	.....	.....	.....	.....	.....	.....
Republic	19	.....	.....	7.2	12.0	.....	18.0	19.9	21.8	.....	.....	.....	.....	.....	.....
Rooks*†‡	35	.....	10.0	.....	12.3	13.1	15.4	19.5	.....	.....	.....	.....	.....	.....	.....
Scott*	102	.....	.....	8.5	9.8	10.7	13.2	14.0	12.4	17.8	20.1	15.0	18.9	.....	26.4
Woodson†	26	.....	.....	11.7	17.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
CITY, COUNTY AND PRIVATE LAKES															
Augusta City Lake, Butler Co.*	76	.....	.....	7.5	8.4	9.7	12.0	15.8	20.5	.....	.....	.....	.....	.....	.....
DeSelm Lake, Stafford Co.	37	.....	6.5	.....	10.6	10.4	11.7	14.7	14.9	20.3	21.7	.....	.....	.....	.....
Gardner City Lake, Johnson Co.‡	29	.....	12.7	.....	13.2	14.0	16.7	24.3	21.9	27.6	.....	.....	.....	30.0	.....
Garnett City Lake, Anderson Co.	21	.....	.....	.....	.....	16.3	16.0	.....	.....	.....	.....	.....	.....	.....	.....
Herington City Lake, Dickinson Co.*	91	.....	5.5	6.8	8.2	8.7	10.0	12.1	.....	.....	.....	24.6	.....	.....	.....
Lakeview, Douglas Co.*	26	.....	6.5	8.6	10.4	13.5	15.8	17.7	.....	.....	.....	.....	.....	.....	.....
Prairie Lake, Jackson Co.‡	43	.....	.....	.....	8.9	11.2	12.0	14.7	13.7	16.7	.....	.....	.....	.....	.....
Shawnee Lake, Shawnee Co.†	35	.....	10.0	16.2	.....	19.3	21.9	22.2	.....	.....	.....	.....	.....	.....	.....
Wabaunsee Lake, Wabaunsee Co.‡	92	.....	8.6	11.2	12.9	14.5	13.8	14.8	14.0	.....	19.9	.....	.....	.....	.....
Wellington City Lake, Sumner Co.*	66	.....	5.3	7.4	9.7	10.6	12.5	14.0	16.0	16.5	19.9	.....	.....	.....	27.2
Wyandotte Co. Lake, Wyandotte Co.†‡	22	6.1	13.0	16.0	.....	9.7	11.8	12.0	17.4	18.1	.....	.....	.....	.....	.....

TABLE 1.—*Concluded*

	No. of Fish	Age in Years													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
FEDERAL IMPOUNDMENTS															
Cedar Bluff, Trego Co.†	84	.....	.....	10.7	7.9	9.3	13.3	26.3	.....	.....	.....	.....	.....	.....	.....
Kanopolis, Ellsworth Co.	165	.....	6.3	8.0	9.5	11.1	12.6	11.5	14.5	19.9	.....	.....	.....	.....	.....
STREAMS															
Kansas River, Douglas Co.	51	2.6	7.1	12.9	16.6	.....	.....	.....	28.1	.....	.....	.....	.....	.....	.....
Mill Creek, Wabaunsee Co.	5	.....	9.7	.....	12.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mud Creek, Leavenworth Co.	7	.....	6.3	.....	8.7	12.3	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rock Creek, Douglas Co.	22	.....	5.2	6.3	8.3	9.7	12.6	13.2	14.7	.....	.....	.....	.....	.....	.....
Saline River, Saline Co.	2	.....	.....	12.8	.....	17.6	.....	.....	.....	.....	.....	.....	.....	.....	.....
Shoal Creek, Cherokee Co.	4	.....	7.1	.....	9.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
AVERAGES															
State lakes	689	2.9	8.4	10.0	13.1	13.3	14.7	17.1	17.1	18.9	25.4	15.0	20.7	.....	26.4
Federal impoundments	249	.....	6.3	9.4	8.7	10.2	13.0	18.9	14.5	19.9	.....	.....	.....	.....	.....
City and county lakes	538	6.1	8.5	10.5	10.3	12.5	14.0	16.2	16.9	19.8	20.5	24.6	.....	30.0	27.2
All impounded waters	1,476	3.7	8.3	10.1	11.7	12.7	14.2	16.9	16.9	19.5	22.5	19.8	20.7	30.0	26.8
Streams	91	2.6	7.1	10.7	11.2	13.2	12.6	13.2	21.4	.....	.....	.....	.....	.....	.....
Statewide average	1,567	3.5	8.0	10.2	11.6	12.7	14.2	16.7	17.3	19.5	22.5	19.8	20.7	30.0	26.8

*—Drained or treated with fish toxins.
†—Stocked with fingerlings or fish from rearing ponds.
‡—Stocked with fish, usually stunted, obtained from other impoundments.

two year-classes, 1950 and 1951, had been stocked in that impoundment. When recaptured in 1954, the fish that had hatched in 1950 were four years old, and those hatched in 1951 were three. The number of annual rings in cross-sections of the pectoral spines of these fish agreed with the known ages. Using fish of known age, Marzolf (1955:244) also verified the technique used to find the ages of channel catfish.

Increase in diameter of the spines is correlated with increase in length of the fish (Sneed, 1951:179-180). Consequently, if the length of the fish and the diameter of the spine at the time of capture are known, the length of the fish at the time of the formation of any annual ring can be estimated by measuring the diameter of that annual ring and calculating the unknown length by use of the following equation:

$$\frac{\text{diameter of spine}}{\text{length of fish}} = \frac{\text{diameter of annulus x}}{\text{length of fish at end of year x}}$$

Computing the length of a fish at the time of formation of a given annual ring, called back-calculation, is reasonably accurate for finding the length of a fish at the time the last (outermost) growth ring was formed. Back-calculated lengths have an increasing error as rings nearer the center of the spine are used (Marzolf, 1955:247-248). The error is inherent in the method of growth of the spine.

In this report the length of each fish at the time the last growth-ring was formed has been calculated to facilitate comparisons.

Table 1 shows the average calculated total length of channel catfish in each of the bodies of water from which samples were analyzed. The impoundments are listed alphabetically under the headings: 1) State Lakes, 2) City, County and Private Lakes, and 3) Federal Impoundments. The statewide average is the average of the two lines in Table 1 labeled All Impounded Waters and Streams. In the computation of all other averages each body of water was given equal weight regardless of the number of fish comprising the sample. Comments concerning the populations in each impoundment and stream comprise the Appendix.

The lakes designated by the symbol D in Table 1 were drained or treated with fish toxin at the time the sample was obtained. Most of these lakes have since refilled and have been restocked. The samples are representative of the old populations, not the new ones.

Because stocking affects the average rate of growth, those im-

poundments that were stocked within five years prior to the time when the sample was taken are designated in Table 1. Fish were stocked from three sources: 1) hatcheries, as fingerlings; 2) rearing ponds, where fingerlings from hatcheries were fed and then released as yearlings or two-year-olds; 3) "wild" populations in various impoundments. The symbol H represents stocking with fingerlings or fish from rearing ponds. The symbol S designates stocking with "wild" fish from other impoundments. The records do not make clear in all cases the source of fish stocked.

The wild fish used were mostly, but not always, stunted. Such fish were obtained when lakes were drained in an attempt to establish better fishing, when lakes went dry, and in the case of those from Kanopolis Reservoir, were obtained by the Forestry, Fish and Game Commission in a special project for utilization of stunted fish to stock other impoundments.

Stocking, regardless of the source of the fish, produces an unnatural population. The growth-rates of fish stocked as fingerlings or yearlings reflect, to a considerable degree, the conditions in the impoundment because they are stocked early in their lives. Fish that spend several years in one impoundment and are then transferred to another reflect the rate of growth in the original impoundment as well as that in the new habitat. For example, fish that had grown slowly for four years and were then moved to better surroundings grew at a faster rate than before, but did not make up for the four years of slow growth. Hence, in impoundments that have been stocked with stunted fish, the tabulated rate of growth is poorer than it would have been without the addition of such fish.

Figure 3 shows the length-weight relationship of channel catfish gathered throughout the state. The graph was drawn by plotting the average length and weight of fish of each year class from all impoundments from which samples were available.

Few channel catfish live longer than seven years. Channel catfish in Gardner Lake, Meade County State Lake, Lake Shawnee and some other impoundments grew to a size acceptable to anglers in two or three years. The earlier in its life a fish attains acceptable size, the longer it will be available to anglers, and the bigger it will become. In Kanopolis Reservoir, Augusta City Lake, Scott County State Lake, and some other impoundments, most of the channel catfish had not attained acceptable size until they were four to six years old. Such fish were available to the angler for a short time only, and few reach large size.

The growth-rates of some fish used in this study were influenced by the drought that existed throughout the state from 1952 to 1957. In most streams and many impoundments the volume of water was less than in the preceding wet years. Consequently, fish were crowded together and had smaller areas in which to feed. Such conditions caused decreased rates of growth.

Another effect of the drought was a decrease in siltation, especially in mainstream impoundments, such as Kanopolis Reservoir and Cedar Bluff Reservoir. Reduced siltation favors rapid growth, but the favorable aspects of clearer water were partly offset by a reduction in the volume of water. Effects of turbidity on the rate of growth of channel catfish are discussed in more detail in the following section.

GROWTH IN RELATION TO MUDDINESS OF WATER

Channel Catfish grow faster in clear impoundments than in those that are muddy. Figure 4 summarizes age-growth data from ten clear impoundments, four muddy ones, and eight of intermediate turbidity. Impoundments in which the water usually contains less than 25 parts of suspended material per million parts of water are considered clear. In muddy impoundments the turbidity is usually in excess of 100 parts per million, and in impoundments classified as intermediate, the turbidity is usually between 25 p.p.m. and 100 p.p.m. but may be either above or below those limits for

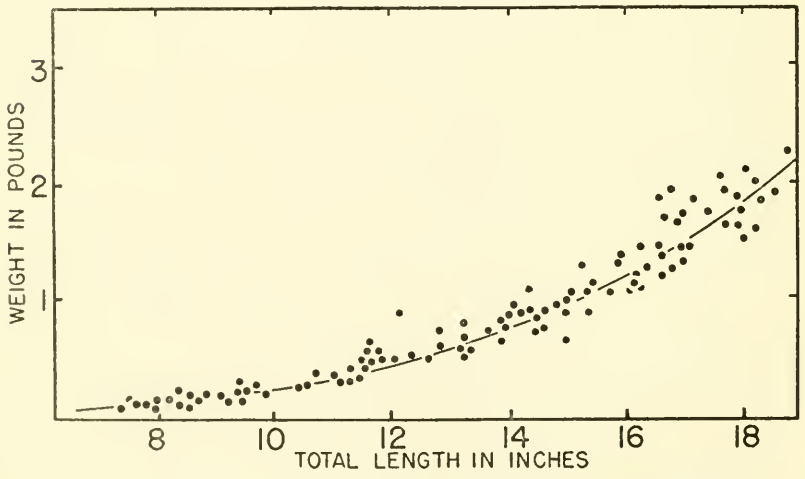

FIG. 3. (part 1). Length-weight relationship of channel catfish.

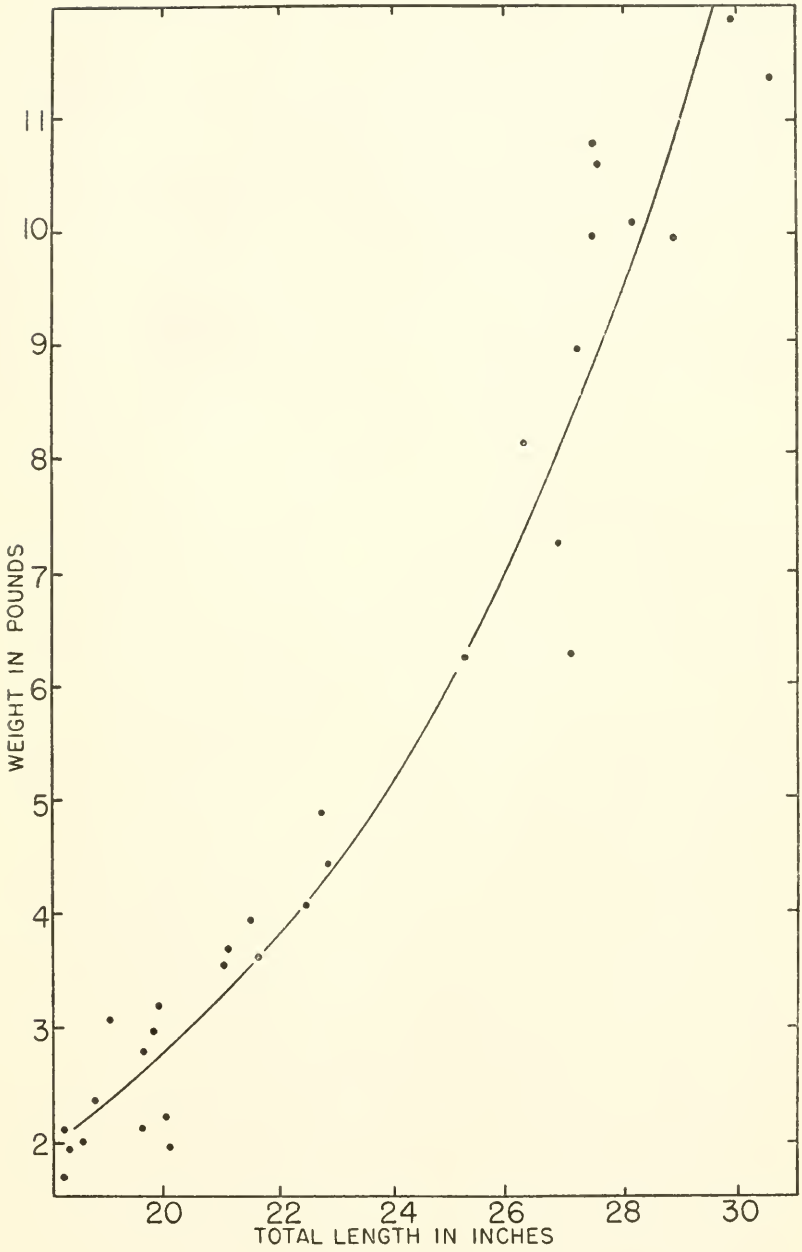

FIG. 3. (part 2). Length-weight relationship of channel catfish.

short periods. A list of the impoundments included in each category follows.

Clear

Cedar Bluff Reservoir
Clark County State Lake
Crawford County State Lake No. 2
Gardner Lake
Leavenworth County State Lake
Pottawatomie County State Lake No. 1
Prairie Lake
Wabaunsee Lake
Woodson County State Lake
Wyandotte County Lake

Intermediate

Lyon County State Lake
Kanopolis Reservoir
Kingman County State Lake
Meade County State Lake
Nemaha County State Lake
Neosho County State Lake
Rooks County State Lake
Shawnee County Lake

Muddy

Augusta City Lake
Decatur County State Lake No. 2
Ottawa County State Lake
Scott County State Lake

Turbidities were measured with a Jackson turbidimeter. This method does not distinguish between turbidity caused by microscopic plants and animals (plankton) and that caused by particles of soil suspended in the water, but the appearance of the water led me to conclude that all readings in excess of 100 p.p.m. were the result of suspended particles of soil. Readings in the intermediate range were caused by both soil and plankton. In clear waters plankton was the cause of any turbidity except when soil had been washed in by heavy rains shortly before the reading was obtained. In this report "turbid" and "muddy" have the same meaning.

In several impoundments from which catfish were obtained, turbidity was not measured because the lakes were drying up during the drought and were examined under unusual conditions, rather than the conditions under which the population developed.

The growth curve for the four muddy impoundments is a closer approximation to that of a natural population than any of the other three curves. Most of the clear and intermediate impoundments were stocked frequently, but only one of the muddy impoundments had been stocked with channel catfish since 1944. That one, Ottawa County State Lake, received a planting of 8,000 catfish on April 11, 1952. Those probably were yearlings that had been held through the winter at the hatchery.

Fish older than seven years are so scarce in the samples that the curves have little reliability beyond that point.

Seven of the ten clear impoundments were stocked with stunted channel catfish in the period from 1952 to 1955; therefore, the growth curve (Figure 4) for this group of impoundments is skewed downward after the fish reached the age of four years. Without

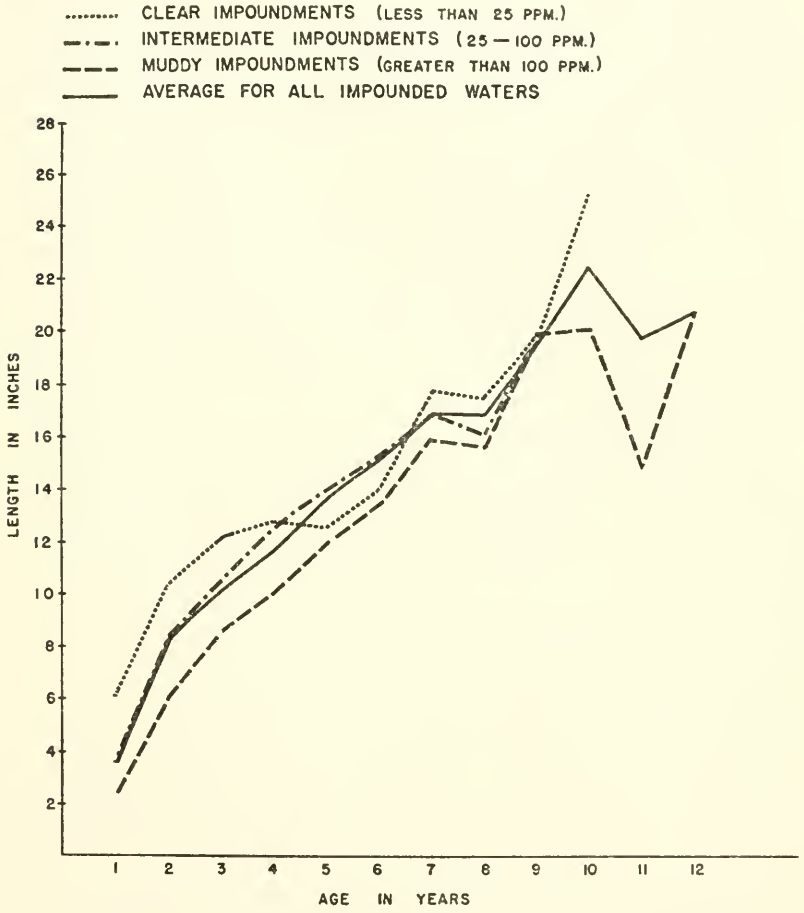

FIG. 4. Growth of channel catfish in relation to turbidity.

the addition of these fish the populations would have been smaller and the average length of the five- to nine-year-old fish would have been greater. Most of the fish transferred from Kanopolis Reservoir were between four and seven years old at the time of transfer. Although stunted fish that were stocked in 1952 and 1953 were not marked, many were recognized because of the similarity between

the pattern of growth rings in their pectoral spines and the pattern in the spines of marked fish transferred in 1954.

Seven of the eight intermediate impoundments, Kanopolis Reservoir being the exception, were stocked at least once in the period 1950-1956. Four of them—Rooks County State Lake, Meade County State Lake, Kingman County State Lake and Lyon County State Lake—were stocked in 1952 or 1953 with stunted fish from Kanopolis Reservoir. Therefore, the growth curve (Figure 4) for intermediate impoundments also is skewed downward for fish more than five years old.

The parts of the curves between one and three years are based on native fish, fish stocked as fingerlings, and fish held in rearing ponds and stocked as yearlings. Even though slightly biased by the fact that some of the fish spent one summer in a hatchery and others spent an additional summer in rearing ponds, the one-year to three-year sections of the curves are more indicative of the potential of the impoundments for producing good fishing for channel catfish than are the data from older fish.

As has been suggested in the preceding discussion of the effects of turbidity on the growth of channel catfish, an important problem in their management is balancing the population with the carrying capacity of the impoundments in such a way that fish of desirable size are produced. The effects of turbidity on population size and the relationship of turbidity to carrying capacity are twofold. An increase in turbidity seems to decrease the availability of food (Wallen, 1955:456), while at the same time increasing the reproductive success of channel catfish. In clear impoundments the carrying capacity is higher than in turbid impoundments because food is more plentiful, but reproduction often fails to maintain a population large enough to support intensive fishing. Impoundments having intermediate turbidity are less likely to require special management for channel catfish than are muddy ones and clear ones.

In clear waters predatory fish and insects probably limit the survival of catfish by preying on the young (Buck, 1956:36, 47). Marzolf (1957:26) found a direct correlation between the survival of young and turbidity, reporting that young were usually found in ponds in which the Secchi disc reading was less than 20 inches (more turbid) and usually were lacking in ponds having more than a 20-inch reading (less turbid). Supporting the supposition that predation is important are the findings by Marzolf (1957:27) that survival

of young catfish was not nearly so high in ponds containing adult largemouth bass *(Micropterus salmoides)* and either bluegill sunfish *(Lepomis macrochirus)* or redear sunfish *(Lepomis microlophus)* as it was in ponds containing only channel catfish. He found 15 one-inch catfish in the stomach of a seven-inch bluegill taken from the nest of a channel catfish. Competition among young channel catfish and other small fish probably does not limit the numbers of catfish to the extent that predation does. When channel catfish, largemouth bass, and bluegill are stocked as fingerlings in the same pond, the catfish survive.

In addition to its effects on the survival of the young, turbidity affects selection of a nest site. Marzolf (1957:23) found that in clear water, fish did not spawn in a single nail keg but did spawn in two kegs attached end to end, making a nest nearly twice as long as a single keg and consequently darker. This evidence indicates that some places utilized as spawning sites in turbid waters would not be used in clear waters.

The major needs in managing channel catfish for sport fishing in Kansas are increasing the number in most clear impoundments and decreasing the number in most muddy impoundments. These problems could be resolved by transferring fish from muddy waters to clear waters, thereby benefitting the sport fisheries of both. A discussion of the transfer of fish from Kanopolis Reservoir to other impoundments follows.

TRANSFER OF CATFISH FROM KANOPOLIS RESERVOIR TO OTHER IMPOUNDMENTS

Kanopolis Reservoir in Ellsworth County is a flood control impoundment of the Smoky Hill River. At the time this study began the reservoir contained a large number of channel catfish, mostly less than 14 inches long. In 1952, 1953 and 1954 the Kansas Forestry, Fish and Game Commission transferred an estimated 54,835 of these catfish between eight and 13 inches long to other impoundments in the state where, it was hoped, they would grow faster than they had in Kanopolis Reservoir and would contribute to the sport fishery of the recipient impoundments.

Methods

Channel catfish were captured by seining in an area baited with partially decomposed carp *(Cyprinus carpio)* and carpsuckers *(Carpiodes carpio).* Bait-fish were caught in the reservoir with a

two-inch mesh seine 200 feet long. The seine used to catch the catfish was 300 feet long, eight feet deep, and had a mesh of one inch, bar measure. This size mesh allowed catfish less than eight inches long and other small fish to escape.

In 1954, when I assisted with the project, seining was more successful just after dawn than later in the morning. No seine hauls were made at night. The seine was laid from a rowboat and hauled by men on shore. The number of catfish caught in one haul varied from none to approximately a thousand. The seiners estimated that they had caught as many as three thousand in some hauls in 1952 and 1953.

The bait was strung on a wire, which was then attached to a stake driven into the bottom in the area to be seined. Because catfish are primarily nocturnal, the bait was put into the water in late afternoon. Attaching the bait to a stake kept the catfish in the area that was to be seined and prevented fouling of the seine with fish carcasses. As soon as the ends of the seine were on the beach so that fish could not escape, the stake and remaining bait were removed before the bag of the seine was pulled ashore.

In 1952 and 1953, fish were taken directly from the seine to a distributing truck, which took them promptly to another impoundment. No provisions were made for holding quantities of fish too small to constitute a full load or for holding any fish in excess of a load.

In 1954, efficiency was increased by installing three metal holding tanks below the dam; there, fish were counted, measured, marked, and retained until it was convenient to move them. The tanks were eight feet long, 2.5 feet wide and had holes 2.5 feet from the bottom to allow overflow.

A stream of seepage water from the base of the dam was directed into the tanks. The temperature of the water entering the tanks varied from 59°F. to 60°F. Transfer from the warm (75°-80°) lake water to the cold water stunned the fish, but they recovered within two hours. Many fish, when placed in the tanks, regurgitated the bait they had eaten. Holding fish for one or more days in the tanks prevented regurgitation in the distributing truck. In 1952 and 1953, when fish were transferred directly from the seine to the truck, regurgitated food clogged the water lines in the truck and hampered distribution, especially on long trips.

In addition to the equipment mentioned above, the following items were used: 1) One outboard motorboat equipped with a

tank and pump for carrying fish from the seine to a truck on shore (at Kanopolis Reservoir much of the shoreline is inaccessible by truck, so fish were carried from the seining site to a convenient road by boat); 2) One pickup truck equipped with a tank and pump to carry fish from the boat to holding tanks; 3) Miscellaneous items—dip nets, buckets, tubs, measuring boards, marking equipment, scales, boots, slickers, gasoline containers, *etc.*

Usually a crew of five men worked at Kanopolis Reservoir, but in 1954 two additional men marked the fish and helped with the seining. The crews worked from two to six weeks each year (total of 12 weeks in three years), but usually seined only three times a week. The members of the seining crew were hatchery workers and game protectors who were temporarily transferred to the work at Kanopolis Reservoir. Labor-costs for removing fish from the reservoir were approximately ten cents per fish.

Efficiency of the operation might be increased if its duration were lengthened, and a temporary crew, such as college students in summer, were hired specifically for the project. Supervised by one experienced employee, this crew could establish camp and seine five or six days per week. Four men are sufficient if the fish are not marked. One or two additional men are required to mark the fish.

Hauling the seine, the most difficult task, can be done by two men on each end. Then, while two men carry the fish to the holding tanks, the other two can dry one seine and prepare the other for catching bait. All four are needed to catch and prepare the bait, but one or two men can set it.

If the catch were approximately 2,000 fish, four men might have to work more than eight hours, but if the catch were small and bait-fish were easily obtainable, the work could be done in fewer than eight hours.

Distribution of Marked Fish

In August, 1954, approximately 1,200 marked channel catfish (some died in transit) were put into each of four impoundments: Crawford County State Lake No. 2 (sometimes called Farlington Lake); Prairie Lake near Holton, Jackson County; Wabaunsee Lake near Eskridge, Wabaunsee County; and Wyandotte County Lake near Kansas City. All fish put into Prairie Lake and Farlington Lake were marked by fin removal but some of the fish released in Wabaunsee Lake and in Wyandotte County Lake were marked

with monel strap tags (National Band and Tag Co. #1005, size 3) attached to the gill cover. Approximately 300 of the fish put into Wyandotte County Lake were left unmarked to see if marking increased mortality in transit. There was no detectable difference in the rate of mortality between marked and unmarked fish. Some marked fish were held in ponds for observation of the marks (see pp. 43-45).

The four lakes that received fish from Kanopolis Reservoir were sampled with gill nets in each of the two succeeding years. Information obtained is discussed on pp. 27-32. In the summer of 1956 the average total length of transferred fish in the four impoundments was 4.8 inches greater than that of fish of the same year classes that remained in Kanopolis Reservoir.

FIG. 5. Contribution of each species to the anglers' catch from Kanopolis Reservoir (data from Schryer, 1955, 1957, 1958).

Status of Channel Catfish in Kanopolis Reservoir

Channel catfish seemed much less abundant in Kanopolis Reservoir in 1955-1957 than they were in 1952-1954, when 55,000 were removed. Evidence of a decline in the population was provided by the rate of capture in gill nets, and by a creel census. In four gill nets set for 14 hours on August 22 and 23, 1955, I caught channel catfish at the rate of 0.61 per hour per 100 linear feet (600 square feet) of net. In the following year I fished four nets of the same kinds for 42 hours in the period from July 30 to August 1 and caught channel catfish at the rate of 0.29 per hundred-foot-hour.

A creel census taken by employees of the Kansas Forestry, Fish and Game Commission (Schryer, 1955, 1957, 1958) showed a marked decline in the catch of channel catfish from 1954 to 1957 (Figure 5). In 1954 the size limit was removed from channel catfish. Previously, the minimum legal length had been 12 inches. The catch of channel catfish in 1954 was the highest on record at 62.2 per cent of the total number of fish caught by anglers. In 1955 this species comprised 25.5 per cent of the total; in 1956, 9.1 per cent; and in 1957 the figure dropped to 6.2 per cent. In 1952 and 1953 the catches of channel catfish were, respectively, 39 per cent and 31 per cent of the total.

The decline from a peak of 62.2 per cent of the total catch in 1954 to a low of 6.2 per cent in 1957 was not caused entirely by a decline in the numbers of channel catfish. White bass (*Roccus chrysops)* and walleye *(Stizostedion vitreum)* were introduced and entered the catch for the first time in 1953. Although the catch of walleyes remained rather low (Figure 5), white bass comprised between 33 and 53 per cent of the creel in 1955, 1956, and 1957. The addition of these two fish would have caused a decrease in the percentage of channel catfish taken, even if the actual number caught had remained the same. However, both the total number of channel catfish caught and the number caught per unit of effort declined. In 1953, fishermen caught channel catfish at the rate of one for each 10.2 hours of fishing. In 1954, with the removal of the size limit, fishermen could keep fish that were previously illegal, and the rate changed to one in four hours of fishing. In 1955, it fell to one in 10.8 hours and in the two succeeding years dropped to one in 25.4 hours and one in 26.5 hours.

The preference of the anglers is a factor that complicates evaluation of the creel census. Probably some fishermen switched their efforts from channel catfish to white bass and walleye as these fish

became more plentiful. Also, fishing for carp seemed to increase in popularity at the time the catch of channel catfish was declining. Scarcity of channel catfish may have been one reason for the shift of emphasis to other species.

The removal of 55,000 channel catfish in three years, a rate of nearly four pounds per acre, or 15.5 fish per acre, contributed to the decline. Carlander (1955:557) reported that the average standing crop of channel catfish in lakes and reservoirs is 15.9 pounds per acre, and the maximum standing crop is 55.4 pounds per acre. The standing crop of channel catfish in Kanopolis Reservoir at the time removal began in 1952 probably was nearer Carlander's maximal than his average figure. The reservoir had filled to its capacity of 450,000 acre-feet of water, covering 13,900 acres, in the summer of 1951 and had been drawn down to the conservation pool of 50,000 acre-feet, covering 3,550 acres, after flood waters had receded. The unusually large volume of water probably resulted in a large crop of fish, which were then crowded into a smaller area as the water-level was lowered. The unusual abundance of channel catfish in Kanopolis Reservoir prompted its selection as a source of fish for other impoundments.

Assuming an initial standing crop of 55 pounds per acre, the removal amounted to 7.3 per cent by weight of the channel catfish. This rate does not take account of any replacement of the fish removed. If reproduction and growth restored the standing crop to 55 pounds per acre each year, the fish removed amounted to only 2.4 per cent of the crop. Actually the rate of removal was greatest in 1952 and least in 1954. I doubt that removal of fish by seining was entirely responsible for the decline in the numbers of channel catfish.

Another factor of importance in the decline was the clearing of the water as the drought progressed. Clear water probably reduced the number of suitable spawning sites and also increased the number of young channel catfish eaten by predators. The effects of turbidity are discussed in more detail on pp. 17-21. Two species of predatory fish, white bass and walleye, were introduced, and it is likely that their depredations contributed to the decline of channel catfish.

In times of normal rainfall channel catfish inhabit streams tributary to Kanopolis Reservoir. As these streams became dry in the early 1950's, channel catfish probably left them and entered the reservoir, but by 1954 such streams were nearly or completely dry and were no longer contributing fish to the reservoir in appreciable numbers.

Growth of Transferred Channel Catfish

Crawford County State Lake No. 2

(Farlington Lake)

Farlington Lake is a clear, steep-sided impoundment with a rocky shore. The area is 150 acres, and the capacity is 3,474 acre-feet (Stene, 1946:135). The water is deep in comparison with other impoundments in Kansas, a considerable part being more than 15 feet deep. The maximum depth is between 40 and 50 feet. Rooted aquatic plants, chiefly hornwort *(Ceratophyllum),* are abundant around the edges to depths of 12 to 14 feet. Andrews and Breukelman (1952:318) considered Farlington Lake a highly productive environment.

Species important in the sport fishery are largemouth bass, bluegill, green sunfish *(Lepomis cyanellus),* white crappie *(Pomoxis annularis),* black crappie *(Pomoxis nigromaculatus),* and channel catfish. Present, but of little or no importance in the angling catch, are spotted bass *(Micropterus punctulatus),* longear sunfish *(Lepomis megalotis),* yellow bullheads *(Ictalurus natalis),* black bullheads (*Ictalurus melas*), white sucker (*Catostomus commersonnii*), drum *(Aplodinotus grunniens),* and brook silversides *(Labidesthes sicculus).*

The lake, formed by damming a stream, was first stocked with bluegill, crappie, largemouth bass, channel catfish and yellow perch *(Perca flavescens)* in 1937. It was opened to fishing in 1939, and fishing has been good since then.

I sampled the lake twice with gill nets before it was stocked in 1954 with fish from Kanopolis Reservoir, and found channel catfish in reasonable numbers. My catch was 0.16 catfish per hundred-foot-hour on May 1-2, and 0.11 per hundred-foot-hour on July 21-23, 1954. Approximately 2,700 unmarked channel catfish from Kanopolis Reservoir had been introduced in 1952, and 2,000 more had been added in 1953. The planting of 1,200 fish from Kanopolis Reservoir in 1954, supplemented by 3,500 fish from the rearing pond at Woodson County State Lake, seemed to maintain the population at approximately the same level that existed in 1954. The catch in gill nets was 0.19 per hundred-foot-hour on April 6-9, 1955, and 0.10 per hundred-foot-hour on July 24-27, 1955. In spite of a planting of 2,500 catfish six to 12 inches long in October, 1955, the population seemed to drop in 1956 to a level slightly below that of the previous summer. The catch on July 4-7, 1956, was 0.07 per hundred-foot-hour. Creel census data were not available, but I

usually saw anglers with good catches of channel catfish when I visited the lake.

Introduced fish grew an average of 6.3 inches in 22.5 months (see Table 2). One sample in addition to those shown in Table 2 was taken on April 7, 8, and 9, 1955. The average increase in length, since August 20, 1954, the time of stocking, of the seven marked channel catfish caught was 1.6 inches.

The ratio of marked to unmarked catfish in the samples is assumed to be an estimate of the contribution of the introduced fish to the fisherman's catch. On the basis of this ratio, the marked fish (only the 1,200 stocked in 1954) comprised approximately 15 per cent of the anglers' catch in the first year after being stocked and about eight per cent in the second year.

Frequent stocking obscured the extent to which spawning by fish in the lake contributed to the population of channel catfish. I believe that fishing for channel catfish was much better than it would have been without stocking.

TABLE 2. GROWTH OF MARKED CHANNEL CATFISH STOCKED IN 1954, AT LENGTHS OF EIGHT TO 13 INCHES, AND RECAPTURED IN GILL NETS IN 1955 AND 1956.

NAME OF IMPOUNDMENT	1955			1956		
	Month	Average increase in length	Number of fish	Month	Average increase in length	Number of fish
Farlington	July	3.9	7	July	6.3	6
Prairie	August	4.1	28	July	7.3	14
Wabaunsee	June	1.0	5	July	4.2	5
Wyandotte	July	3.5	5	June	8.8	2

Prairie Lake

Prairie Lake, less than six miles northeast of Holton, has an area of 78 acres and a maximum depth of 25 feet. The water is clear, although the banks are not rocky and their slope is gradual. Pondweeds (*Potamogeton* spp.) grow around the margin to a depth of three to four feet.

At the time channel catfish were introduced from Kanopolis Reservoir, the fish population consisted of bluegill, largemouth bass,

both black and white crappie, a few black bullheads, and a few channel catfish. According to Mr. Carl DeBusk, the caretaker, fishermen occasionally caught channel catfish weighing five pounds or more, but these large fish were more common than small ones. Seemingly, channel catfish were not maintaining their numbers.

The growth of introduced fish is shown in Table 3. At the end of two years these fish had grown an average of 8.9 inches. The data in Table 3 were obtained from records kept by Mr. DeBusk and from my records of fish caught in gill nets. Mr. DeBusk recorded the length, the mark, and the date of capture of channel catfish caught by fishermen. Because of other duties, he was unable to interview all fishermen, and there is no accurate method of ascertaining the number of catfish removed from the lake by angling.

Both Mr. DeBusk's records and my gill-net samples indicate that the introduced fish were supporting almost all of the channel catfish fishery. In August, 1955, I caught 28 channel catfish in gill nets set for 82.5 hundred-foot-hours (rate of 0.34 per hundred-foot-hour). All of these fish were marked. In July, 1956, I set gill nets for 220 hundred-foot-hours and caught 14 channel catfish (rate of 0.06 per hundred-foot-hour). Again, all were marked. I know of but three unmarked channel catfish caught during the period of this study. Mr. DeBusk recorded two, each 28 inches long and weighing 10 pounds, and I saw a fisherman catch one 23.7 inches long that weighed four pounds and 12 ounces. The pattern of growth-rings

TABLE 3. AVERAGE INCREASE IN LENGTH OF CHANNEL CATFISH TRANSFERRED FROM KANOPOLIS RESERVOIR TO PRAIRIE LAKE IN AUGUST, 1954.

DATE	Average increase in length (inches)	Number of fish
May 21-30, 1955	1.7	19
June 4-24, 1955	2.0	7
July 9-31, 1955	3.9	32
* August 9, 1955	4.1	28
August 3-29, 1955	4.4	38
September 5-30, 1955	5.1	13
October 2-8, 1955	5.0	6
May 15-18, 1956	6.8	2
June 8-30, 1956	7.0	8
* July 3-4, 1956	7.3	14
July 1-28, 1956	7.7	30
August 4-12, 1956	8.9	8

* Gill net samples.

in the pectoral spine of the last fish indicates that it had not come from Kanopolis Reservoir.

There is no evidence that reproduction by adult channel catfish in Prairie Lake will maintain a satisfactory fishery. The combination existing there of clear water and smooth mud bottom is not conducive to spawning. Nesting sites are scarce. Continued stocking will be necessary to maintain good fishing for channel catfish.

Wabaunsee Lake

Lake Wabaunsee is similar to Farlington Lake in its physical characteristics. It has an area of 202 acres, a capacity of 3,458 acre-feet (Stene, 1946:136), and a maximum depth of 40 to 45 feet.

The kinds of fish living in this impoundment were almost the same as those in Farlington Lake, but white suckers, carp, and drum were more common than in Farlington and the yellow bullhead was not known to occur in Wabaunsee.

After 23 months in Lake Wabaunsee, introduced channel catfish had increased in length an average of 4.2 inches (see Table 2). On July 26, 1958, a fisherman caught a tagged channel catfish 18 inches long that weighed two pounds. This fish had grown 6.7 inches and gained one pound and ten ounces after it had been stocked on August 26, 1954, a period of almost four years. The slow rate of growth of transferred fish in Lake Wabaunsee, in comparison with those in other impoundments, suggests that the population was at the useful carrying capacity of the lake and that no stocking was necessary at the time the sample was taken. Stocking may be needed later.

Channel catfish reproduced in Lake Wabaunsee. In 1956, unmarked fish less than four years old comprised 27.5 per cent of the sample (11 of 40). Two of these fish had been hatched in 1954 and nine in 1953. These unmarked fish were not a part of the 1954 planting; furthermore, it is unlikely that the nine older fish were a part of the planting from Kanopolis Reservoir on July 29, 1953. The fish stocked at that time were from eight to 12 inches long. Channel catfish do not attain a length of eight inches in two months, the age they would have been at the time fish were stocked from Kanopolis. Therefore, the fish of the 1953-year class and the 1954-year class were hatched in Lake Wabaunsee. There is no record of an introduction that could account for these unmarked fish.

In June, 1955, approximately nine months after marked fish were introduced, these fish comprised 9.3 per cent (five of 54) of the

catfish caught in gill nets. In July, 1956, the ratio of marked to unmarked fish in a sample of 40 was 12.5 per cent. This apparent increase in the proportion of marked fish in the population may be due to sampling error or to death of older stock from Kanopolis Reservoir (1952 and 1953 plantings).

Wyandotte County Lake

Wyandotte County Lake is approximately 305 acres in extent, has a capacity of 6,900 acre-feet (Stene, 1946:135) and a maximum depth of 45 to 50 feet (45 feet on November 25, 1954). The main body of the lake is rather deep with steeply sloping shores, but the upper end and some coves have extensive areas less than 10 feet deep. The shore is mostly clay but is rocky in some places. Rooted aquatic vegetation is scarce. A small bed of water lilies grows in the upper end of the lake.

The fish population was first sampled with gill nets and hoop nets in May, 1954. Judging from that sample and subsequent samples, the sport fishery was supported largely by white crappie and black bullheads. Black crappie were fairly common, but other sunfishes (largemouth bass, bluegill) seemed scarce. Channel catfish were rare. I caught none in 292.5 hundred-foot-hours of netting in 1954, and reports from fishermen also indicated scarcity of channel catfish. Other species present were carp (common but not excessively abundant), drum (scarce), and white suckers (scarce). The sport fishery of Wyandotte County Lake was, in my opinion, the poorest of the four lakes stocked with marked channel catfish. No creel census records were available for any of the lakes, with the exception of those for a brief period for Wyandotte County Lake.

Introduced fish grew an average of 8.8 inches in 22 months (Table 2). The Park Board employed a creel census clerk, Mr. John Bondank, in September, 1954. From September 11 to October 28, 1954, he measured 12 marked fish. Of these, three had been tagged and nine had been fin-clipped. The average increase in total length of the fin-clipped fish was 0.8 inch, whereas the average increment of the tagged fish was 0.4 inch. In the period from June 1 to June 17, 1955, the census clerk measured two tagged channel catfish and three marked by fin-clips. The average increment of the fin-clipped fish was 2.4 inches, and the average increment of the tagged fish was 1.2 inches. After that time the creel census clerk was assigned duties on the park patrol and no more records of the catch were obtained.

Anglers at Wyandotte County Lake returned to me tags from six channel catfish caught in the summer of 1955. Four of the fishermen reported the lengths of the tagged fish. The average increment of the four fish was 3.0 inches. On July 17, 1957, a fisherman caught a tagged channel catfish 26 inches long that weighed seven pounds and two ounces. This fish had grown 15 inches and gained six pounds and 12 ounces after it had been put into the lake on August 26, 1954, a period of almost three years. On July 29, 1958, a tagged channel catfish weighing nine pounds and four ounces was caught but the tag number was not recorded. No tagged fish weighing more than ten ounces were put into the lake in 1954; therefore, the fish gained a minimum of eight pounds and ten ounces in nearly four years.

In 1955, 90 per cent (nine of ten) of the channel catfish caught in gill nets in Wyandotte County Lake had been transferred from Kanopolis Reservoir. Therefore, it can be assumed that these fish were supporting most of the sport fishery. Even so, the number of catfish introduced was so small in comparison with the size of the impoundment that the fisherman's catch was meager.

Eight yearling channel catfish were caught in gill nets in Wyandotte County Lake in June, 1956. The occurrence of these fish may mean that adults in the lake (possibly some of those transferred from Kanopolis Reservoir) reproduced successfully in 1955. However, unmarked fingerlings of the 1955 year-class were stocked. This stocking obscured the success or failure of reproduction.

The fact that the population of channel catfish was so small before the fish from Kanopolis Reservoir were introduced suggests that reproduction by adults in the lake under present conditions, will not produce enough fish to maintain the population at the level that the lake will support. Stocking will be necessary to maintain a successful sport fishery.

Questionnaires

In an attempt to learn if the introduction of fish from Kanopolis Reservoir increased angling success appreciably, fishermen were asked, by means of a questionnaire, to compare the 1955 season with the 1954 season. Fish were introduced late in the 1954 season, so it might be expected that their effect would be more pronounced in the 1955 season. The questionnaires (Figure 6) were left with boat liverymen, caretakers, and license agents at the four lakes.

These people were instructed only in the mechanics of marking the questionnaires, and were given no indication of the answers expected or of the possible effects the answers might have on policies for fisheries management. Table 4 is a tabulation of the answers. Fifteen per cent of the usable replies stated that fishing for channel catfish was better in 1955 than in 1954, 78 per cent said that it was worse, and seven per cent said the two seasons were the same.

The answers contradict other evidence about the fish populations in the four impoundments. Prairie Lake is an example. In most of the 1954 season fishing was provided by native fish only. Fish from Kanopolis Reservoir were introduced in August and the fishing season ended early in October. In the two times that I sampled the population with gill nets (total of 302.5 hundred-foot-hours) I caught no channel catfish native to Prairie Lake; therefore, it is highly unlikely that enough native fish were present to make the 1954 fishing season better than the 1955 season. The populations of channel catfish in the other three impoundments are discussed on pages 27-32.

In the absence of creel census data to show what the fishermen actually caught, interpretation of the answers to the questionnaire is uncertain. In view of information from other sources, I believe that stocking improved the fishing, or at least prevented its deterioration. The answers to the questionnaires seem to show that most fishermen do not remember their fishing success from one year to the next, and that questionnaires of the kind that I used are not a reliable means of evaluating a project such as was undertaken.

Did you fish for channel catfish in Prairie Lake in both 1954 and 1955?

Yes No

In 1955, fishing for channel catfish in Prairie Lake was

better than worse than the same as

it was in 1954

(Underline the correct words.)

FIG. 6. Questionnaire used to compare the 1954 and 1955 fishing seasons at Prairie Lake.

TABLE 4. COMPARISON OF 1955 FISHING SEASON (CHANNEL CATFISH ONLY) WITH THE 1954 SEASON, BASED ON FISHERMEN'S ANSWERS TO QUESTIONNAIRES.

NAME OF IMPOUNDMENT	Better		Worse		Same		Total No.
	Percent	No.	Percent	No.	Percent	No.	
Farlington..	21	6	68	19	11	3	28
Prairie.....	7	3	93	41	0	0	44
Wabaunsee	63	5	25	2	13	1	8
Wyandotte	11	6	78	42	11	6	54

PRODUCTION IN PONDS

With the recent increase in the number of small ponds, the importance of learning about the culture of channel catfish in them is greater than ever before. Ponds can provide fish for sport, food, or market.

My work was hampered by the severe drought of 1952-1956, but a few experiments were continued long enough to yield information about the rate of growth of channel catfish in ponds.

Three ponds containing no other fish were stocked with fingerling channel catfish obtained from the state hatchery in December, 1954. Ponds 2 and 3 at the University of Kansas Fisheries Laboratory at Lawrence and a farm pond in Chase County were used. The ponds at the University are of identical size and shape, each being one-tenth of an acre in area and having an average depth of approximately two feet, though the depth fluctuated during the experiment. Each of these ponds was stocked on December 29, 1954, with 50 fingerlings (rate of 500 per acre). The average total length of these fish at the time of stocking was 3.5 inches, the average weight, 0.02 pound. Experiments were conducted with marking these fish by the removal of fins; results of marking are reported on pp. 40-43.

The pond in Chase County was stocked on December 12, 1954, with 150 fingerlings having an average total length of 3.9 inches and an average weight of 0.02 pound. The area of this pond is approximately one acre and the average depth is approximately three feet, but the waterlevel fluctuated considerably during the drought.

Fish in the three ponds were captured at intervals and weighed and measured (Table 5). Average increase in length and average increase in weight are based on the average length and weight of

the fish at the time of stocking. Pond 2 was drained in February, 1957, and 41 fish weighing a total of 18.3 pounds were recovered.

These experiments show that channel catfish can be raised to a size desirable for consumption by the third summer after they

TABLE 5. GROWTH OF CHANNEL CATFISH STOCKED AS FINGERLINGS IN THREE PONDS.

DATES	Months since stocked	Average total length	Average increase in length	Average weight	Average increase in weight	Number fish in sample
	Pond Number 2 at the University of Kansas					
Mar. 12, 1955	3	3.7	0.2	.....	.....	9
June 22, 1955	6	6.9	3.4	0.12	0.10	18
Aug. 10, 1955	7	9.1	5.6	0.20	0.18	29
Feb. 25, 1956	14	9.8	6.3	.....	.....	13
Aug. 27, 1956	20	11.7	8.2	0.43	0.41	15
Feb. 9, 1957	26	11.7	8.2	0.47	0.45	41
	Pond Number 3 at the University of Kansas					
Mar. 12, 1955	3	3.6	0.1	.....	.....	12
June 22, 1955	6	6.3	2.9	0.08	0.06	32
	Chase County, Sec. 5, R6E, T. 20S					
June 26, 1955	6	7.0	3.1	0.10	0.08	18
April 14, 1956	16	10.7	6.8	0.19	0.17	11
June 24, 1956	18	12.2	8.3	0.48	0.46	26
Sept. 8, 1956	21	13.3	9.4	0.62	0.60	23

are hatched, without supplemental feeding or any special treatment. Production under such conditions was somewhat in excess of 100 pounds per acre.

A pasture pond in Chase County was stocked in October, 1948, with 500 bluegill and crappie (the records do not say how many of each, nor are the crappie identified to species), 400 largemouth bass, and 700 channel catfish. All of these fish were young of the year (1948). Eight years later, in 1956, I helped John J. Sharp and Willard Jones, State Game Protectors, seine the pond, and on the basis of the sample, decided to poison the remaining fish and restock. Fishing had not been satisfactory, according to E. E. Koger, the manager of the ranch, and the waterlevel had dropped considerably because of the drought.

The fish were killed on September 30, 1956; the pond was only 2.5 feet deep and the area was approximately 0.73 acre. When the pond is full the maximum depth is eight feet and the area is approximately 4.5 acres. The fish had been stocked at the rate of 155 channel catfish, 110 bluegill and crappie, and 90 bass per acre.

After the fish were poisoned with rotenone (concentration slightly in excess of one p.p.m.), 137 channel catfish, four largemouth bass, and one flathead catfish were recovered. The average weight of 57 of the eight-year-old channel catfish was 2.1 pounds, and the average total length, 19 inches. The flathead catfish weighed 3.1 pounds and was 20.4 inches long. Three of the largemouth bass weighed between three and 3.3 pounds; and the other weighed one pound.

All of the channel catfish were from the original stocking. If any had spawned in the pond, the fry did not survive. The standing crop of channel catfish when the pond was poisoned was 288 pounds (395 pounds per acre). Had the pond been at spillway level the standing crop would have been approximately 64 pounds per acre. Other fish present were orangespotted sunfish *(Lepomis humilis),* red shiner *(Notropis lutrensis),* fathead minnow *(Pimephales promelas),* and black bullhead.

The fish population of another pond situated in a Flint Hills pasture was examined nine years after it had been first stocked. Some of the fish in this pond died in July, 1954, as a result of depletion of the dissolved oxygen, and the remaining fish were killed with rotenone in November, 1954.

Fish that died in July, when the oxygen supply became low, were large channel catfish, largemouth bass (mostly ten to 12 inches long), black crappie, and white crappie (about eight inches long). When rotenone was put into the pond in November, the following kinds of fish were killed: white crappie, black crappie, green sunfish, carp, bigmouth buffalofish *(Ictiobus cyprinella),* and black bullheads. Black bullheads held in cages suspended in the water at the time rotenone was added died in less than one week, and in subsequent work on the pond no fish other than those stocked were found, indicating that the rotenone eliminated all of the fish.

The original planting of fish in this pond consisted of channel catfish, largemouth bass, crappie, and perhaps bluegill. Other species were introduced by fishermen or entered through the spillway at times of overflow.

The five nine-year-old channel catfish that I found dead in July were from 24 to 26 inches long. I did not weigh them because they were partially decomposed. The owner of the pond had removed some others but had kept no count. When the pond was poisoned, one other channel catfish, a small one 15.2 inches long weighing 1.17 pounds, was found. This fish also appeared to be

nine years old. Possibly it was put into the pond by fishermen between July and November.

Channel catfish eight to 13 inches long were transferred from Kanopolis Reservoir to eight ponds in August, 1954. Those in three ponds died early in the period of study, and in some others growth was poor. The fish in these ponds were used to evaluate different marking methods, as well as to ascertain their rate of growth in farm ponds. The growth of these fish is shown in Table 6.

TABLE 6. GROWTH OF STUNTED CHANNEL CATFISH IN PONDS.

POND (Size and location)	Date of sample	Average increase in length	Number fish in sample	Stocking rate	Average turbidity
Aunt Annie's					
1.3 acre	Oct. 24, 1954	-0.1	20	77/A	415
Marion County	Aug. 5, 1955	0.1	1	.....	.....
Sec. 34, R.5E, T.20S	Aug. 2, 1956	0.3	15	.....	.....
LLL 17					
3 acre	Nov. 7, 1954	0.0	9	21/A	287
Chase County	June 25, 1955	0.1	10	.....	.....
Sec. 17, R.6E, T.20S	July 22, 1956	0.4	4	.....	.....
Gerstenberger's					
1.5 acre	June 23, 1955	0.4	27	67/A	100***
Douglas County	June 23, 1956	1.0	17*	.....	.....
Sec. 32, R.21E, T.13S	Aug. 3, 1956	1.8	19**	.....	.....
Kampschroeder's					
0.75 acre	Oct. 31, 1954	0.8	2	80/A	32
Douglas County	June 21, 1955	3.0	9	.....	.....
Sec. 17, R.18E, T.13S	July 21, 1956	6.2	14	.....	.....
Butell's					
1 acre	June 5, 1955	2.7	1	19/A	50***
Douglas County	July 14, 1955	4.5	1	.....	.....
Sec. 13, R.19E, T.15S	April 16, 1956	7.2	1	.....	.....

* Gerstenberger's records.
** Near total population.
*** Estimated.

A correlation between high turbidity and slow rate of growth was evident in these ponds. Within the ranges used in this experiment, turbidity seemed to exert stronger influence on the rate of growth than did the number of fish per acre. Comparison of the stocking rates and growth of the fish in the Gerstenberger pond with those in the Kampschroeder pond supports this conclusion. The other ponds listed in Table 6 contained fish in addition to the

channel catfish stocked by me; therefore, the stocking rates do not indicate the total number of fish per acre.

Fifty-one fish ranging from eight to 13 inches in total length were transferred from Kanopolis Reservoir to pond 1 at the University of Kansas Fisheries Laboratory on August 27, 1954. Approximately 100 minnows (*Notropis lutrensis* and *N. stramineus*) were introduced in the winter of 1954-1955. The pond was drained on December 5, 1956, and 45 channel catfish weighing a total of 18.2 pounds and approximately 21,000 minnows weighing a total of 10.2 pounds were recovered. Also recovered were an estimated 5,500 tadpoles weighing 24.9 pounds.

When the pond was drained, the stomachs of 37 of the fish were examined. Sixteen were empty; 14 contained one or more insects; 13 contained minnows; eight contained frogs; two contained isopods; one contained unidentifiable material. Thirteen stomachs contained a total of 45 minnows distributed as follows: six stomachs contained only one; four contained three minnows; one contained four; one contained seven; and one contained 16. After minnows, insects were the most frequent item in the stomachs, a total of 29 having been found in 14 stomachs.

This pond was sampled by seining and the fish were measured. The fish grew, on the average, only 0.8 inch in 20 months, even though minnows were available to them (see Table 7).

TABLE 7. GROWTH OF CHANNEL CATFISH IN POND 1.

DATE WHEN SAMPLED	Average length in inches	Average weight in pounds	Number of fish
Dec. 23, 1954	10.4	.....	15
June 18, 1955	10.6	0.31	34
Aug. 26, 1956	11.2	0.37	21
Dec. 5, 1956	11.6	0.37	45

MARKING CHANNEL CATFISH

Frequently in management of a fishery it is important to recognize fish from certain groups; for example, those stocked at different times or those originating from different sources. The two methods having the greatest practicality for most purposes are tagging and the removal of one or more fins. Tags—small, numbered, non-corrosive metal clips crimped into the jaw or gill cover of the fish—

identify the individual fish, but tagging requires more time than fin-clipping does. The removal of a fin or a combination of fins does not provide identification of individual fish, but this may not be necessary. Usually the objective is to recognize fish as members of a group, such as hatchery-reared fish stocked at a certain time. There is some evidence that removal of fins inhibits the growth of fish less than does tagging (Pechacek, 1956:120). Clipped fins frequently heal sooner than punctures made by tags. Clipped fins seem not to hinder swimming appreciably. Because of the advantages of fin-removal over tagging, my experiments stressed the former method.

Methods of marking channel catfish so they could be recognized when recaptured were tested on both hatchery-reared fingerlings and fish eight to 13 inches long (obtained from Kanopolis Reservoir). Fish were measured, weighed (in some cases) and marked, and were then put into ponds and larger impoundments. Later

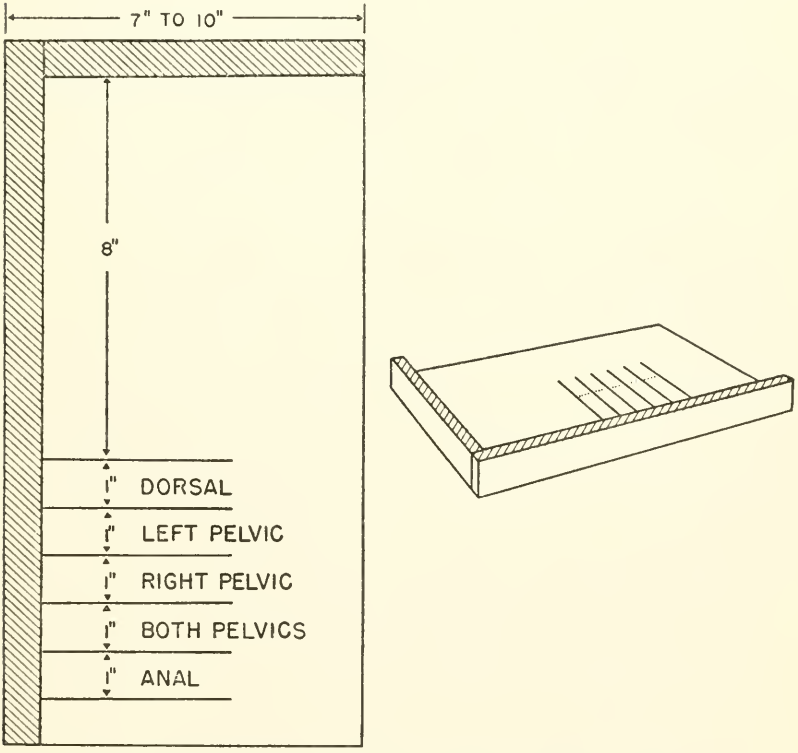

FIG. 7. Measuring board used in marking channel catfish.

the marked fish were captured with seines or gill nets and weighed and measured again, and the condition of the mark was noted.

Fish to be marked were anesthetized in a 0.5 per cent solution of urethane (ethyl carbamate) in water. Although urethane is an effective anesthetic, its use is not recommended because of its carcinogenic properties (Wood, 1956). Ten to 15 fish were put into a tub containing the urethane solution and were removed one at a time, measured, marked, and returned to holding tanks. One person recorded the number of fish marked by each fin-clip while another cut off the fins. Dissecting scissors were used to remove soft-rayed fins. Dorsal and pectoral fins were removed by means of wire cutters. Fish were measured on a board marked as shown in Figure 7. When a fish's snout was placed against the left margin, the fin to be removed was indicated by the label of the column in which the tip of the tail lay. Fins removed in the various experiments are shown in Figure 8.

Marks on Fingerlings

Marks on fingerling channel catfish were tested in pond 2 at the University of Kansas Fisheries Laboratory. The pond was stocked on December 29, 1954, with 50 fingerlings having an average total

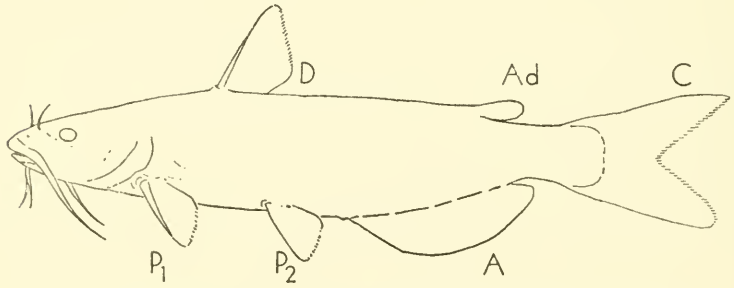

Fig. 8. Fins removed from channel catfish in marking experiments. A, anal fin; Ad, adipose fin; C, caudal fin; D, dorsal fin; P_1, pectoral fin; P_2, pelvic fin, $\times \frac{1}{4}$.

length of 3.5 inches (see p. 53). Ten fish were marked by removal of the dorsal fin, ten by removal of one pectoral fin, ten by removal of one pelvic fin, ten by removal of the adipose fin, and ten were left unmarked to serve as a check on the effect of removal of a fin on growth of the fish.

The conditions of the marks were noted when the fish were caught in seines and weighed and measured. Table 8 shows the extent

TABLE 8. REGENERATION OF FINS BY CHANNEL CATFISH MARKED WHEN FINGERLINGS.

	Date examined			
	Aug., 1955	Feb., 1956	Aug., 1956	Feb., 1957
DORSAL FIN:				
Average increase in length of fish, in inches	5.6	5.9	8.4	7.8
Average increase in length of fin, in percent	22*	79	67	71
Number of individuals	6	2	3	6
PECTORAL FIN:				
Average increase in length of fish, in inches	5.2	5.8	7.8	8.0
Average increase in length of fin, in percent	76	87	83	80
Number of individuals	3	4	2	3
PELVIC FIN:				
Average increase in length of fish, in inches	5.2	.....	9.7	8.3
Average increase in length of fin, in percent	83	.....	71	84
Number of individuals	6	0	1	4
ADIPOSE FIN:				
Average increase in length of fish, in inches	5.8	6.6	7.3	8.3
Average increase in length of fin, in percent	2*	5	26	17
Number of individuals	5	4	1	8
UNMARKED:				
Average increase in length in inches	5.9	7.1	8.3	8.1
Number of individuals	9	3	8	12

* Expressed in mm., percentage not computed.

of regeneration of fins. The numbers in the columns headed "average regeneration" are ratios of the average maximum linear growth of any part of the fin to the length of a normal fin of a fish the same length. They do not denote the percentage of the area of the fin that had been regenerated.

The sample of 33 fish taken on February 9, 1957, was obtained when the pond was drained (Table 8). Nine fish had been removed in October, 1956, leaving eight unaccounted for. The fish had been in the pond for 25 months.

All ten of the fish marked by removal of the adipose fin were accounted for. That mark remained recognizable for the duration of the experiment, with regeneration varying from none to 36 per cent. Removal of the adipose fin seems satisfactory for marking fingerling fish to be used in long-term studies. Probably regeneration of this fin would be lessened if the fin were removed with a hot wire rather than with scissors as I did. Scissors, because of

their thickness, do not remove the fin at the base, but leave a small stump.

Removal of the dorsal fin seems also to be a satisfactory mark for long-term studies. The percentage of regeneration of this fin was far greater than that of the adipose fin, but regenerated dorsal

TABLE 9. REGENERATION OF FINS (EXPRESSED IN INCHES, TENTHS AND HUNDREDTHS THEREOF) BY CHANNEL CATFISH EIGHT TO 13 INCHES LONG WHEN MARKED.

	Date of recapture									
	Oct., 1954	Nov., 1954	Jan., 1955	Apr., 1955	June, 1955	July, 1955	Aug., 1955	June, 1956	July, 1956	Aug., 1956
DORSAL FIN:										
Average increase in length of fish..	.....	.....	0.4	2.4	0.7	3.9	4.4	7.6	6.6	.....
Average increase in length of fin...	.....	.....	.12	.52	.00	.00	.68	2.00	.60	.....
Number of individuals.....	0	0	2	1	2	1	7	1	1	0
LEFT PELVIC FIN:										
Average increase in length of fish..	0.3	.....	0.1	1.6	1.0	4.4	4.1	.....	1.9	1.6
Average increase in length of fin...	.04	.....	.12	.64	.28	.36	.88	.....	.76	.56
Number of individuals.....	3	0	5	2	9	4	5	0	3	4
RIGHT PELVIC FIN:										
Average change in length of fish..	-0.4	0.1	0.1	1.4	0.8	4.3	3.8	10.0	5.2	.....
Average increase in length of fin...	.04	.04	.08	.40	.28	.32	.56	1.20	.88	.....
Number of individuals.....	17	2	8	3	19	3	10	1	16	0
BOTH PELVIC FINS:										
Average change in length of fish..	-0.1	0.2	-0.1	1.5	1.1	3.6	3.6	.....	5.2	2.2
Average increase in length of fin...	.08	.04	.04	.40	.24	.28	.08	.....	.88	.92
Number of individuals.....	6	4	6	1	12	3	7	0	7	4
ANAL FIN:										
Average change in length of fish..	0.7	-0.3	0.0	.....	0.7	3.1	.....	.....	7.6	.....
Average increase in length of fin...	.08	.08	.12	.....	.12	.48	.....	.....	.80	.....
Number of individuals.....	5	3	7	0	9	1	0	0	2	0

fins were recognizable by pronounced deformity that accompanied regeneration. The spinous ray usually grew with a bend directed either posteriorly or to one side, and the other rays were frequently crooked, especially so if growth was to the side rather than upward.

Although regeneration of the dorsal fin may be greater than regeneration of the adipose fin, fish marked by removal of the dorsal fin probably would be noticed by fishermen, whereas those marked by the less conspicuous adipose fin might go unnoticed.

As is shown in Table 8, regeneration of pectoral and pelvic fins was greater than that of the other fins. Only seven fish recognizable as having been marked by these two clips were recovered when the pond was drained. In contrast to the dorsal fin, regenerated pectoral and pelvic fins usually were not obviously deformed, and were distinguishable from the normal fins only by being shorter. No marks could be discerned on 12 of the 33 fish obtained when the pond was drained. Because only ten unmarked fish were originally put into the pond, at least two seemingly unmarked fish had regenerated the fin to such an extent that the mark was no longer recognizable. Removal of the pectoral or pelvic fin is not a satisfactory method for marking fingerling channel catfish that are to be held through one growing season. For work of shorter duration these marks could be used with safety.

Marks on Larger Fish

The fish transferred from Kanopolis Reservoir to other impoundments in 1954 were marked by the removal of fins or by tags. Some of these fish were held in ponds for observation of the marks.

Table 9 is a summary of the amount of regeneration of fins by channel catfish that were eight to 13 inches long when they were marked in August, 1954. The increase in length of each fish was computed by subtracting from its total length at the time of capture the mean of the size-group designated by each mark. For example, all recaptured fish marked by removal of the dorsal fin (mark used for fish between eight and nine inches long) were assumed to have been 8.5 inches long when they were transferred. Size-groups were designated as follows:

Length of Fish	Fin Removed
8-9 inches	Dorsal
9-10 inches	Left pelvic
10-11 inches	Right pelvic
11-12 inches	Both pelvics
12-13 inches	Anal

Regeneration was less in larger fish than in fingerlings. Many fins had healed and not grown at all. Most of those with appreciable regeneration were readily recognizable because of malformation. Usually, fewer than the normal number of rays were regenerated and these frequently were crooked.

In addition to the marked fish discussed above, small numbers of fish eight to 13 inches long were used to test a few other marks. These fish were held in pond 1 at the University of Kansas Fisheries Laboratory. Fins removed were the adipose fin, the upper lobe of the caudal, or tail fin, and a portion of the anal fin. The pond was drained at the end of 27 months, and the marks were examined.

Different portions of the anal fin were removed from nine fish. The fin rays were severed with front-cutting nippers. From three fish the anterior one-third was removed; from three the middle one-third; and from three the posterior one-third. The three fish marked by the removal of the middle portion of the fin were recognizable at the end of the experiment. Regeneration of cut rays was slight, but the anterior portion of the fin folded back into the space and growth of the membrane gradually filled the notch. This mark probably would not be noticed by a fisherman unless he were especially observant. One of the three fish marked by removal of the anterior one-third of the anal fin was recovered. The fin rays were regenerated to approximately the same length as the intact rays but slanted posteriad at a greater angle. Two of the fish marked by removal of the posterior one-third of the anal fin were recognized at the end of the experiment. In both cases the fin was nearly normal in shape, but the posterior rays were farther apart than in an uninjured fin.

The five fish marked by removal of the upper lobe of the caudal fin were recognizable at the end of the experiment. Although part of the fin grew to nearly normal shape, the uppermost rays did not. Failure of growth by the uppermost rays left a notch at the base of the fin.

Removal of the adipose fin proved to be a satisfactory mark for fish eight to 13 inches long, as well as for those of fingerling size. All five of the larger fish so marked were recovered at the end of the experiment, and in no case had there been any regeneration.

Tags

Monel strap tags (National Band and Tag Co. #1005, size 3) were attached to 335 channel catfish that were transferred from Kanopolis Reservoir to Wyandotte County Lake and Wabaunsee

Lake, and five fish held in pond 1 at the University of Kansas Fisheries Laboratory were so marked. The tags were placed on the gill cover, piercing the opercle. Each tag was numbered and bore the inscription, "Return Univ. Kans."

Twenty-two tags were recovered from the two lakes in four years. Three of the fish were caught in gill nets that I set and the remainder were caught by fishermen who either mailed the tags to the University or left them with boat liverymen and park personnel.

The number of tags shed by the fish is unknown. Three of five tagged fish held at the Fisheries Laboratory had the tags in place after 28 months. The fourth fish had a healed scar presumably left when the tag was shed. The fifth is unaccounted for. Other evidence that some tags were shed was obtained when a tag from a channel catfish was caught on a gill net. Probably a fish with a loose tag became entangled in the net and then escaped but left the tag snarled in the mesh. Pelgen and McCammon (1955:261) reported considerable loss of strap tags of the same style but smaller size from white catfish *(Ictalurus catus)* after 22 months. These authors concluded that the strap tag is unsatisfactory.

Pelgen (1954:315-319) and McCammon (1956:327-329) described a disc-dangler tag and a hydrostatic tag that seem satisfactory for channel catfish.

The number of captures of tagged fish was too small to allow a comparison between their growth and the growth of fin-clipped fish. In the three cases in which fin-clipped and tagged fish were caught at the same time, the fin-clipped fish showed greater growth (see pp. 31-32); however, a fisherman reported catching a tagged channel catfish that had gained at least eight pounds and ten ounces in nearly four years. That was the largest of the marked fish reported to me. No data from fin-clipped fish taken at the same time are available for comparison.

SUMMARY AND RECOMMENDATIONS

1. Rate of growth and length attained at the end of each year in 28 impoundments and six streams are presented in Table 1.

2. Channel catfish rarely live more than seven years. Therefore, production of fish attractive to anglers requires favorable environments early in the life of the fish. Fishing is unsatisfactory where channel catfish do not attain a length of 12 inches within four years.

3. Channel catfish grow faster in impoundments of clear water than they do in muddy impoundments, but clear impoundments usually contain fewer channel catfish than muddy impoundments.

4. In spawning, any kind of nest site that is acceptable in clear water is acceptable in muddy water, but in muddy water additional sites are used. Therefore, more young are produced in muddy water than in clear water.

5. Predatory fish probably eat more young channel catfish in clear water than they do in muddy water, because predators probably can find their prey more easily in clear water than in muddy water.

6. In most impoundments in which the turbidity is less than 50 parts per million, anglers catch few channel catfish unless fish six or more inches long are stocked. Mainstream reservoirs probably do not need such stocking. In impoundments having light fishing pressure or good fishing for species other than channel catfish, regular stocking may not be economically feasible. Fishing pressure on a given impoundment and the chances of providing a satisfactory sport fishery by means of other species ought to be considered before that impoundment is stocked with channel catfish.

7. Stunted fish that are moved from poor to better environments grow rapidly, but such fish should be transferred when they are between one and five years old if the sport fishery is to obtain maximum benefit from the transfer.

8. A possible alternative to stocking is the provision of spawning sites, for example, nail kegs and terra cotta pipe, in clear waters. Adding spawning sites might increase reproduction enough to feed the predators and to supply young fish for the sport fishery. Controlled experiments with terra cotta pipe, or other permanent structures are recommended.

9. In muddy impoundments having a native population of channel catfish, the fishing will not be improved by stocking more channel catfish.

10. Channel catfish can be raised to a desirable size (approximately 12 inches and eight ounces) in pounds within three growing seasons without feeding the fish or fertilizing the water.

11. Channel catfish usually do not spawn in clear ponds but will spawn if structures suitable for nests are provided.

12. As a means of marking channel catfish, metal strap tags were attached to gill covers. For the same purpose the upper lobe of the caudal fin and one-third of the anal fin were removed. Tests of permanency of both methods were inconclusive.

13. Channel catfish marked by the removal of pectoral or pelvic

fins, when the fish are fingerlings, cannot be identified after one growing season because the fins are regenerated.

14. Channel catfish marked by the removal of the adipose fin or the dorsal fin, when the fish are fingerlings, can be identified two years later.

15. Channel catfish eight to 13 inches long at the time they are marked by removal of dorsal, pelvic, anal, or adipose fins can be recognized two years later.

APPENDIX

Status of Channel Catfish in Kansas Waters

The populations of channel catfish in each of the bodies of water sampled are discussed in the following pages. The lakes and streams are listed alphabetically under the following headings: 1) State Lakes, 2) City, County, and Private Lakes, 3) Federal Impoundments, and 4) Streams. The rate of growth of the fish and the size of the samples are shown in Table 1, pp. 12-13.

STATE LAKES

Clark County State Lake

Clark County State Lake, situated in a canyon, is deep and clear. When sampled in April, 1954, the lake contained enough channel catfish to provide good fishing. The rate of growth shown in Table 1 is not representative of fish native to the lake, because it had been stocked frequently with fish from many sources. Records kept by the Forestry, Fish and Game Commission show that an estimated 14,700 channel catfish were put into the lake from 1952 through 1955. At least half of that number were stunted fish from Kanopolis Reservoir and Finney County State Lake. The stunted fish make the rate of growth seem poorer than it is. Stocking obscured the success of reproduction, but I believe that few channel catfish were produced naturally and that periodic stocking benefited the fishery.

Crawford County State Lake No. 2
(Farlington Lake)

See pages 27-28.

Decatur County State Lake No. 2

The samples from Decatur County State Lake were obtained by biologists of the Forestry, Fish and Game Commission in April and May, 1955, when the lake was being drained. At that time channel catfish were too numerous for the food supply. They were not growing fast enough to provide satisfactory fishing. The oversupply resulted from reproduction by fish in the lake, no channel catfish having been stocked since 1944.

No samples were analyzed after the lake was restocked, but fishing probably will again be poor.

Kingman County State Lake

Kingman County State Lake was drained and restocked with fingerling fish of several species in 1954. The channel catfish attained a length of 9.5 inches by the end of August, 1955, a rate of growth well above the average.

Leavenworth County State Lake

Channel catfish in Leavenworth County State Lake came from at least two sources and probably three. Fish from the hatchery at Pratt were held in a rearing pond and put into the lake as yearlings; older fish from Kanopolis Reservoir were put into the lake in 1952; and adults in the lake probably reproduced. The extent to which spawning was successful is unknown, but indications are that periodic stocking substantially benefits fishing. The rate of growth of the channel catfish was better than average for impounded waters of the state in spite of the fact that some stunted fish had been stocked.

Lyon County State Lake

When Lyon County State Lake was sampled in 1954 and 1955, the channel catfish seemed to be reproducing satisfactorily. Fish from Kanopolis Reservoir were stocked in 1952, but no young fish had been stocked since 1944. In Table 1, the fish less than five years old were native to the lake. They were growing fast enough to provide reasonably good fishing, attaining in their fourth year a size considered worthwhile by anglers.

Meade County State Lake

My sample of channel catfish from Meade County State Lake was too small to permit conclusions. The lake was stocked with approximately 2,500 stunted channel catfish from Kanopolis Reservoir in 1952. The success of reproduction is not known, but some probably occurs. The water was within the intermediate range of turbidity on the few occasions in 1955 and 1956 when I saw the lake. Andrews and Breukelman (1952:317) reported a turbidity of 140 p.p.m., mostly caused by algae, in August, 1947.

Nemaha County State Lake

Channel catfish in Nemaha County State Lake were too numerous in relation to the food supply to provide good fishing. Most fish did not attain a size considered worthwhile by anglers until the fifth or sixth year of life. Although the water was rather turbid during 1954, some clearing occurred in recent years. This trend, if it continues, may result in an increased rate of growth by channel catfish.

Neosho County State Lake

The turbidity of Neosho County State Lake was in the lower part of the intermediate range, usually being less than 50 p.p.m. in the period of my study. The rate of growth of channel catfish was sufficient to provide good fishing because they had attained acceptable size in their fourth year. The success of reproduction has been obscured by stocking, but native channel catfish probably would not be numerous enough to support a satisfactory fishery. The present program of stocking with six- to ten-inch fish should be continued.

Ottawa County State Lake

Ottawa County State Lake was too muddy to provide good fishing for channel catfish in 1955 and 1956. Fish did not attain a length of 12 inches until their fifth year and then continued to grow slowly (see Table 1). Stocking

small catfish in this lake would be detrimental to the fishing. At the time of my study, reproduction maintained a population larger than the food supply would support; consequently the fish became stunted. Unless the turbidity of the water is reduced, this lake will produce few game fish of desirable size. Andrews and Breukelman (1952:323) stated that this lake is destined to be a turbid, bullhead-carp environment.

Pottawatomie County State Lake

The sample taken on July 21, 1955, from Pottawatomie County State Lake consisted of but two fish. Both the small size of the sample in relation to the effort expended, and the rapid rate of growth of the fish, indicate that the population of channel catfish was small. Reproduction by adults in this clear lake did not maintain the population at a level high enough to provide satisfactory fishing. Periodic stocking with yearlings is advisable.

Republic County State Lake

The sample of channel catfish from Republic County was obtained from a small creek tributary to the lake. The fish suffocated under the ice in February, 1956. Growth of these fish was satisfactory, but may not be representative of growth in this shallow, turbid lake.

Rooks County State Lake

Rooks County State Lake became low during the drought and was drained in 1958 so that the spillway could be repaired. Andrews and Breukelman (1952:323) reported that in August, 1947, the water was turbid, rooted aquatic vegetation was sparse, and the potential productivity of the lake was low. In July, 1954, when I visited the lake, the water was of intermediate turbidity, but this turbidity appeared to be caused largely by plankton and suspended organic material rather than by silt. Rooted aquatic vegetation was growing around much of the shore. The growth of channel catfish that had been transferred from Kanopolis Reservoir in 1952 seemed satisfactory, and those fish largely supported the fishery. Reproductive success was slight.

Because of the changes that occurred between 1947 and 1954, it is difficult to predict what will happen when the lake is restocked. If heavy rains muddy the water, fishing probably will be poor, but if the turbidity remains below 50 p.p.m. fishing should be good.

Scott County State Lake

The sample taken from Scott County Lake was obtained when the lake was drained in 1955. For several years prior to 1955 the lake had been muddy, and the rate of growth of channel catfish reflects the adverse effects of excessive siltation. Table 1 shows that channel catfish attained a length of 13.2 inches, on the average, by the end of their sixth year.

While dry, the lake bed was seeded with millet in an attempt to stabilize the silt and to add organic material. In the fall of 1955 the lake was refilled and stocked with 5,000 young-of-the-year channel catfish as well as with bass, bluegill and crappie. The water remained clear until a heavy rain in the

summer of 1956 washed in a large quantity of silt that has remained in suspension. The outlook for fishing is poor.

Woodson County State Lake

In 1949 Woodson County State Lake was drained and the bed was seeded with lespedeza and sweet clover. The lake began refilling in 1950 and was stocked with largemouth bass, bluegill, crappie, and channel catfish. Growth of channel catfish was excellent, the average length of four-year-old fish being 17.1 inches. The lake was sampled too soon after being restocked to indicate whether reproduction will be successful. The clarity of the water and the flourishing population of bass, bluegill, and crappie lead me to expect that an insufficient number of young will be produced to maintain the fishery. Periodic stocking with yearling or older channel catfish will probably be necessary.

CITY, COUNTY, AND PRIVATE LAKES

Augusta City Lake

Growth-rates of the channel catfish obtained from Augusta City Lake (August, 1955), Herington City Lake (November, 1956), and Wellington City Lake (March, 1954) were similar (Table 1). The three lakes were similar in other respects. The waterlevels became extremely low as a result of protracted drought, and the fish populations were eradicated with fish toxicant. Large quantities of silt were in suspension, at least while the lakes were low and probably previous to that time, making the water too muddy for game fish to grow satisfactorily.

Conditions were favorable for spawning by channel catfish and for survival of the young, but siltation so reduced the availability of food that growth was very poor.

DeSelm Lake

Channel catfish in DeSelm Lake were growing too slowly to provide good fishing. The sample was obtained in July, 1955, by seining.

Gardner City Lake

Gardner City Lake was sampled with gill nets in 1955 after having been stocked in 1953 with 1,200 channel catfish from Kanopolis Reservoir. The irregular rate of growth shown in Table 1 is the result of mixing fish that had grown slowly prior to their transfer with the rapidly growing members of the small native population. Fish caught by anglers as well as those taken in gill nets were utilized in my study.

The rapid rate of growth of the native fish in Gardner Lake is evidence that there was, in 1955, sufficient food to support more channel catfish than were present. Two two-year-old channel catfish having an average length of 12.7 inches were caught. These fish were hatched in the lake.

In an attempt to increase the spawning success of channel catfish, the City of Gardner, aided by fishermen, placed a number of terra cotta and wooden nest-structures in the lake in 1956. The effect of these on the fishing cannot yet be evaluated. If the addition of nest-structures does not increase the population of channel catfish appreciably, periodic stocking will be necessary.

Garnett City Lake

In 1955 the channel catfish fishery at Garnett City Lake was being supported by two year-classes. Most of those fish have since been caught or have died. Because reproduction was not maintaining the population, periodic stocking will be necessary to produce adequate fishing for channel catfish.

Herington City Lake

See discussion of Augusta City Lake, p. 51.

Lakeview

Lakeview, an oxbow of the Kansas River in Douglas County, was treated with rotenone in February, 1954, to kill the fish after the waterlevel had dropped severely. Growth of channel catfish had been somewhat slow (Table 1). The age-distribution of the fish indicates that reproduction had been successful.

Prairie Lake

See pages 28-30.

Shawnee County Lake

The rate of growth of channel catfish in Shawnee County Lake was excellent in 1954 and 1955, but the population was small in spite of periodic stocking. Fishing pressure was heavy. Frequent stocking has obscured the contribution, if any, of native fish to the population. The lake would support more channel catfish than were present. Stocking should be continued.

Wabaunsee Lake

See pages 30-31.

Wellington City Lake

See discussion of Augusta City Lake, p. 51.

Wyandotte County Lake

See pages 31-32.

Kahola Lake

Channel catfish from Kahola Lake were examined but were not listed in Table 1 because they were so badly stunted that I could not confidently assign ages to them. The lake has since been drained and restocked.

FEDERAL IMPOUNDMENTS

Cedar Bluff Reservoir

Channel catfish hatched in 1951 were more numerous in the samples taken from Cedar Bluff Reservoir than all other year-classes, comprising 72 per cent (23 of 32) of the sample in 1955, and 83 per cent (43 of 52) in 1956. The 1951 year-class hatched as the reservoir filled for the first time. Probably, the rapidly expanding habitat and the lack of predators (resulting from the small population of native predators in the river) permitted an unusually high rate of survival of young channel catfish. Growth by fish of the large 1951 year-class

was slow. In 1955 their average total length was 7.9 inches and in 1956 it was 8.8 inches.

The water in Cedar Bluff Reservoir was clear, but insect larvae, which usually are important in the diet of channel catfish, were scarce in samples taken from the bottom mud in 1955. If insects become more plentiful as the reservoir matures, the growth-rate of the catfish should improve.

Kanopolis Reservoir

See pages 21-26.

STREAMS

With the exceptions of the Kansas River and Rock Creek, the samples from streams were too small to warrant conclusions; therefore, only those two will be discussed individually. Growth of the channel catfish in most streams was probably somewhat slow because of the drought.

Kansas River

Specimens used in the age-growth study of channel catfish from the Kansas (Kaw) River came largely from Douglas County, with a few from the vicinity of Manhattan having been sent to me by fishermen. The rate of growth of these fish was satisfactory, an average length of 12 inches being attained in the third year.

Rock Creek, Douglas County

The sample from Rock Creek was collected after winter-kill in January, 1954. The stream had stopped flowing as a result of drought. Growth in the summer preceding death had been slight, probably because of the drought.

ACKNOWLEDGEMENTS

My investigations were supported jointly by the Kansas Forestry, Fish and Game Commission and the State Biological Survey of Kansas. Messers Roy Schoonover, Charles Burner, and Frank Schryer, fisheries biologists employed by the Forestry, Fish and Game Commission, collected many of the fish used in the study and provided helpful information and suggestions. Mr. Seth Way, Superintendent of Hatcheries, provided information about propagation of channel catfish. Game Protectors and Park Superintendents throughout the state were helpful.

Permission to use ponds on their land was granted by Mr. Herman J. Butell, Jr., Mr. Wilson Counts, Mr. Homer Gerstenberger, Mr. Charles Holmes, Mr. Robert Kampschroeder, Mr. E. E. Koger, Mr. and Mrs. Ernest Lalouette, and Mr. and Mrs. August Lalouette. I am especially indebted to Mr. and Mrs. Lalouette for their hospitality and intense interest in the work. Discussions with them helped to clarify some of the problems encountered in the investigation.

Assistance in the field was rendered by Messers Lyle K. Stemmerman, Harvey Jansen, Andre R. Brillaud, LeRoy O. Homan, Mac D. Homan, Dennis Rainey, Joseph T. Davis, Claude E. Hastings, and Dr. Kenneth B. Armitage.

The Wyandotte County Board of Park Commissioners and Mr. Clifton Roberts, Executive Director, granted permission to study channel catfish in

Wyandotte County Lake and collected data concerning marked fish. The City Commission of Holton and Mr. Stanley D. Fisher, City Manager, allowed me to study channel catfish in Prairie Lake. Mr. Carl DeBusk, caretaker of Prairie Lake, obtained records of channel catfish caught there. Mr. Abe Cox, Superintendent of Shawnee County Park, co-operated in the work at Lake Shawnee. Officials of the town of Eskridge granted permission for studies on Lake Wabaunsee.

Mr. James Marsh collected data from channel catfish caught at Crawford County State Lake No. 2.

Sportsmen throughout the state expressed interest, provided information, and collected fish.

I am grateful to Mrs. Jane S. Mengel for her help in the preparation of illustrations and for stenographic work and to Mr. Gene Pacheco for the preparation of Figures 1, 2, and 8. I am especially grateful to Dr. Frank B. Cross for his guidance and criticism throughout the course of the work. Professors E. Raymond Hall, Rufus H. Thompson, and A. Byron Leonard read the manuscript and gave helpful advice.

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